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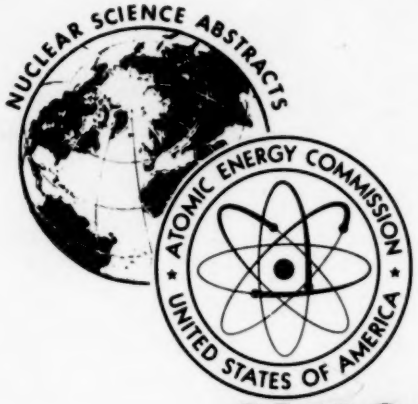


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Volume 18, Number 16, August 31, 1964

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Volume 18, Number 16 August 31, 1964

# NUCLEAR SCIENCE ABSTRACTS

# BIOLOGY AND MEDICINE

## General

**27002** (ORNL-3601) BIOLOGY DIVISION SEMI-ANNUAL PROGRESS REPORT FOR PERIOD ENDING FEBRUARY 15, 1964. (Oak Ridge National Lab., Tenn.). May 1964. Contract W-7405-eng-26. 232p.

Separate abstracts were prepared for 20 sections of this report covering radiobiology research studies. (C.H.)

*For abstracts of individual papers see: 27003, 27004, 27005, 27006, 27007, 27008, 27009, 27010, 27011, 27012, 27013, 27014, 27032, 27064, 27065, 27066, 27067, 27068, 27209, and 27210.*

**27003** (ORNL-3601(p.27-46)) CYTOLOGY AND GENETICS. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on the distribution of x ray and ultraviolet-induced mutations to the chromosome strands in Paramecium; an evaluation of autoradiographic methods for studying overall cell growth; studies on chemical mutagenesis in Paramecium; induced temperature-sensitive mutations in Paramecium; the DNA content of ultraviolet-irradiated Tetrahymena; the role of RNA synthesis in regeneration in Stentor coeruleus; mutagen-directed nucleotide replacements in DNA; photoreactivable lesions in DNA; ultraviolet resistance of Micrococcus radiodurans; the action spectrum for killing and DNA synthesis delay in Micrococcus radiodurans; purification of the photoreactivating enzyme from yeast; the effect of far-red radiation on mitosis in Vicia faba root tips; the kinetics of neutron and x-ray induced chromosome aberrations in barley; the mechanism of the effect of 5-fluorodeoxyuridine on chromosomes; effects of postirradiation centrifugation on chromosome aberrations in Tradescantia microspores; the isolation of fixed metaphase chromosomes; mutagen specificity in Neurospora; the inhibition of DNA synthesis and mitosis in mammalian cells by ultraviolet and x rays; the randomness of induced chromosome breaks by ultraviolet and 5-bromodeoxyuridine; the competitive growth of hematopoietic cells in lethally irradiated mice; the isolation of serum esterase in mice; and the amino acid composition of tryptic peptides of mouse hemoglobin. (C.H.)

**27004** (ORNL-3601(p.47-59)) DROSOPHILA CYTOLOGY AND GENETICS. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies of genetic damage in entire x-bearing and y-bearing genomes x irradiated in mature spermatozoa of Drosophila melanogaster; a search for sex-linked recessive lethals in Drosophila melanogaster that can be transmitted by triploid females but not by diploid daughters; the effects of the amount and distribution of x-chromosome heterochromatin on x-ray-induced x-autosomal translocation frequencies; meiotic behavior of tandem compound ring chromosomes and tandem metacentric compound x chromosomes in Drosophila; preparation of a revised edition of the mutants of Drosophila melanogaster; regulation of fourth chromosome nondisjunction by the length of a free x duplication in Drosophila melanogaster; the genetic explanation for the correlated appearance of diverse karyotype abnormalities within human kinships; spontaneous and x-ray-induced exchange in normal and inverted x chromosomes in Drosophila females; abnormal chromosome behavior associated with the mutant claret-nondisjunctional in Drosophila; and a study of mutant types at the notch locus in Drosophila. (C.H.)

**27005** (ORNL-3601(p.60-8)) CYTOCHEMISTRY AND CELL REPRODUCTION. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies of cell reproduction and related cytochemical reactions. Data are included from studies of nucleic acid synthesis in Tetrahymena pyriformis; the cytological responses of brown adipose tissue in cold-exposed rats; the induction and properties of chromosome puffs in Drosophila; mutation rates of a supersuppressible yeast mutant during mitosis and meiosis; and x-ray-induced breakage of lampbrush chromosomes of Triturus pyrrhogaster or Triturus viridescens. (C.H.)

**27006** (ORNL-3601(p.69-82)) CELL GROWTH AND DIFFERENTIATION. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies of cell growth and differentiation during embryogenesis and lens regeneration in amphibians. Results are reported from studies on the inhibitory effects of actinomycin and x radiation on the lens regenerating system of adult Triturus viridescens; the localization and appearance of specific fractions of lens proteins in transformation of iris into lens; the localization of DNA synthetic activity in lens-regenerating systems; and the histochemical analysis of histones in the regenerating lens. Studies on amphibian embryogenesis reported include the formation of the nucleolus during embryogenesis of Triturus pyrrhogaster; the effect of actinomycin on the development of embryos of Xenopus laevis; autoradiographic studies of processes underlying embryonic induction in Triturus pyrrhogaster; and neural induction and nuclear RNA synthesis in the ectoderm of embryos of Triturus pyrrhogaster. (C.H.)

**27007** (ORNL-3601(p.83-91)) MAMMALIAN GENETICS. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on the relative biological effectiveness of neutrons and x radiation for the induction of gene mutations in mouse postspermatogonial stages; the mutation frequency of dominant skeletal abnormalities in mice; the time of death of mice homozygous for small deficiencies; translocations induced in mouse spermatocytes by treatment with triethylenemelamine; and a comparison of spermatogonial populations in male mice surviving single and fractionated x radiation doses of 1000 r. (C.H.)

**27008** (ORNL-3601(p.146-51)) CHEMICAL CO-CARCINOGENESIS. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on the effects of several chemical carcinogens in various biological test systems. Aerobacter aerogenes autotrophs subject to thymine-less death were isolated by the aminopterin-5-bromodeoxyuridine method and metabolic activities were compared with those of a similar Escherichia coli autotroph. The chemical carcinogens 20-methylcholanthrene and 1,2,5,6-dibenzanthracene were found to have no mutagenic effect on Neurospora crassa. Data are included from studies of the growth response to 6-methylaminopurine of Neurospora mutants blocked in different steps of the adenine biosynthesis investigated for use as a test system of the mutagenicity of various compounds in Neurospora. Bone marrow injections in mice were found to aid hemopoietic recovery from the toxic effects of intraperitoneally administered 9,10-dimethyl-1,2-dibenzanthracene, a chemical carcinogen in mice, even though it did not increase 30-day survival. (C.H.)

**27009** (ORNL-3601(p.152-72)) CELL PHYSIOLOGY. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies of cell physiology. Data are presented on the culture of the flagellate Astasia longa and the sensitivity of synchronously dividing cells to x radiation; the role of polyribosomes in protein synthesis in the ciliate Tetrahymena pyriformis; the development of a cell culture system for monitoring $O_2$ and $CO_2$ changes with nonsterile electrodes; the synchronization of cell division in Tetrahymena with a repetitive temperature cycle; the development of an improved automated carbohydrate analyzer for use in incubation studies on microorganisms; the development of techniques and ultracentrifuge equipment for the isolation of particles in the size and density range of normal viruses from tissue homogenates; the preparation of a plot of sedimentation coefficients and densities of subcellular particles and viruses, based on literature data; development of zonal centrifuges to separate particles covering a size range from whole cells to protein molecules; the development of geometry for use in calculating the flow of water in multicompartmented cells and tissues during freezing; a study of the effect of the warming rate on the survival of yeast cells frozen centrifugally; the role of freezing in the formation of thymine dimers by ultraviolet irradiation; water and ice relationships in bacteriophage T4; and the isolation of a messenger-RNA-containing fraction from E. coli B. (C.H.)

**27010** (ORNL-3601(p.174-86)) NUCLEIC ACID ENZYMOLOGY. (Oak Ridge National Lab., Tenn.).

Progress is reported on studies of nucleic acid enzymology. Data are presented on the biochemical transformations of bacteriophage T2 DNA; the specificity and mechanism of synthesis of the structural proteins of Escherichia coli ribosomes; amino acid specificity in protein synthesis; enzymic condensation of oligodeoxyribonucleotides; the oligonucleotide nature of acid-soluble RNA in ovarian eggs of Rana catesbieana; the properties of nucleases in maize; the isolation, purification, and properties of phosphodiesterase from brine shrimp eggs; tracer studies of RNA synthesis in bacteriophage; and the desalting of nucleic acid and its derivatives by metal hydroxide precipitation. (C.H.)

**27011** (ORNL-3601(p.188-206)) ENZYMOLOGY. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies of amino acid incorporation and protein synthesis in a number of cell-free systems prepared from Escherichia coli, Clostridium pasteurianum, rat liver, and maize; the purification of DNA-dependent RNA polymerase from Escherichia coli; the isolation of ribonuclease from Escherichia coli ribosomes; the cell-free synthesis of $\beta$-galactosidase; amino acid incorporation by extracts of Escherichia coli; the inhibition of macromolecular synthesis in Escherichia coli by ultraviolet radiation; amino acid incorporation by cell-free extracts of Clostridium pasteurianum; the isolation of a soluble amino-acid incorporating system from rat liver homogenates; the effects of light on protein synthesis in plants; the isolation of DNA-dependent ribonucleotide incorporating activity from maize seedlings; the study of factors regulating protein synthesis in regenerating rat liver; nucleic acid synthesis in extracts from nucleoli from rat Novikoff ascites tumor; configuration studies on rat liver polysomes in solution; the effect of actinomycin on the immune response in rats; cell-free synthesis of sheep erythrocyte hemagglutinin; isolation and purification of specific transfer RNA; isolation and purification of amino-acid-activating enzymes; the stimulation of nuclear RNA synthesis in rats by hydrocortisone; steroid-nucleic acid interactions in vitro; the effects of testosterone on RNA synthesis in rat seminal vesicle; hormonal control mechanisms in rat hepatoma in tissue culture; the role of lactic dehydrogenase isozymes in mammalian cell regulation; and the energetics of sulfur metabolism in autotrophic bacteria. (C.H.)

**27012** (ORNL-3601(p.207-9)) MICROBIOLOGY. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on bacterial metabolism Data are included on the preparation and characterization of a monosubstituted naphthoquinone from Streptococcus faecalis; the effects of chemical structure on the conformation in solution of a pyridine nucleotide; and studies on the bound pyridine nucleotide of malic-lactic transhydrogenase. (C.H.)

**27013** (ORNL-3601(p.210-15)) PLANT PHYSIOLOGY AND PHOTOSYNTHESIS. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on plant physiology and photosynthesis. Data are presented on the biological relations between extent of growth, duration of growth, and growth rate for determinate growth of plants; the radiosensitivity of growth in wheat epiblast, coleorhiza, and root hairs; effects of galacturonic acid on elongation of roots of germinating wheat; cell division and initiation of lateral root primordia in germinating wheat; and the role of fluorescence in energy conversion during photosynthesis. (C.H.)

**27014** (ORNL-3601(p.216-21)) BIOPHYSICS. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on x-ray-induced free radicals in crystalline amino acids; the production of dry spores of Bacillus megaterium; the effects of x irradiation on the metabolism of $^3$H-thymidine in the slime mold, Physarum polycephalum; mechanisms of photoreactivation in Escherichia coli; and the effects of ultraviolet radiation on the formation of thymine dimers. (C.H.)

**27015** (TID-4203) RESEARCH AND DEVELOPMENT IN PROGRESS— BIOLOGY AND MEDICINE, APRIL 1964. Issue No. 3. (Division of Biology and Medicine, AEC and Division of Technical Information Extension, AEC). 722p.

Brief summaries are presented of research and development studies in the fields of biology and medicine performed under contracts with the AEC Division of Biology and Medicine in effect in April, 1964. Indexes are included for subject, principal investigator, and contractor. (C.H.)

**27016** (TID-20708(p.6-28)) BIOCHEMISTRY AND PLANT PHYSIOLOGY. (Inter-American Inst. of Agricultural Sciences, Turrialba, Costa Rica).

Progress is reported in tracer studies of plant physiology. Data are presented from studies of S metabolism in Rhodospirillum rubrum; S mobilization in cacao seeds; the cold sensitivity of cacao seeds; the effects of sugars and alcohols on endogenous respiration in cacao embryos; and the effects of Krebs cycle intermediates on respiration in cacao embryos and cotyledons. (C.H.)

**27017** (TID-20708(p.42-51)) CYTOGENETICS AND MUTATION STUDY ON BEANS. (Inter-American Inst. of Agricultural Sciences, Turrialba, Costa Rica).

Progress is reported in studies on the cytology of beans (Phaseolus vulgaris) and attempts to develop a strain resistant to Rhizoctonia, that causes a severe bean disease in wet tropical areas. More than 120 independent chlorophyll mutants and also other types of mutants were isolated from the $R_2$ generation from 4000 seeds exposed to 12 kr $\gamma$ radiation. The mutation rate induced by this dose of $\gamma$ radiation was determined to be 25 times greater than the spontaneous rate. (C.H.)

**27018** (TID-20714) A STUDY OF MATHEMATICAL MODELS OF MUTATION AND SELECTION IN MULTI-LOCUS SYSTEM. Annual Progress Report, September 1, 1963–August 31, 1964. R. C. Lewontin (Rochester, N. Y. Univ.). June 15, 1964. Contract AT(30-1)-2620. 9p.

Progress is reported in genetic studies in Drosophila populations. A computer program was developed for use in studies on the influence of linkage on changes in gene and gamete frequency in a hypothetical population of Drosophila consisting of 500 males and 500 females, each with 30 loci, mating at random with discrete generations. Data are also included from studies on 5-locus models, the effects of isolation by distance on populations of finite size, studies on auto-incompatibility, selection of polygenic characters, selection of components of fitness, and the intrinsic rates of increase in Drosophila populations. (C.H.)

**27019** (TID-20719) A PROGRAM FOR THE STUDY OF TRANSPLANTATION OF BONE MARROW, TISSUES, AND WHOLE ORGANS AND OF RELATED TOPICS IN SURGICAL RESEARCH. Progress Report, 1958-1964. Francis D. Moore (Peter Bent Brigham Hospital, Boston). June 15, 1964. Contract AT(30-1)-2265. 45p.

Results are summarized from a 6-year study of body composition, endocrinology, metabolism, immunosuppressive reactions, and organ and tissue transplants in patients with various diseases. Data are included from preliminary immunological studies in animals, and studies in man on body composition, energy exchange, endocrinology, metabolism after surgery, the endocrinology of carcinoma of the breast, therapeutic use of colloidal $^{198}$Au in pleural metastases, liver diseases, liver function, and the use of hypothermia and hepatic transplantation in the treatment of certain liver diseases. Emphasis was placed on the outcome of kidney transplants in patients after immunosuppression by whole-body irradiation or chemotherapeutic means using 6-mercaptopurine, imuran, or azoserine. Clinical data are summarized on 40 patients given kidney transplants. The effects of local irradiation of the transplanted tissue on immune reactions are discussed. Immunologic studies in animals involved the transplantation of ovarian and parathyroid tissues and whole-organ transplants of liver, spleen, and pancreas. Millipore filter studies and studies on the postmortem survival of tissues are also reported. (80 references.) (C.H.)

**27020** CONCEPTS OF THE RADIOBIOLOGICAL INVESTIGATIONS AT THE INSTITUTE FOR BIOLOGY AND AGRICULTURE, SEIBERSDORF REACTOR CENTER. K. Kaindl (Osterreichische Studiengesellschaft fur Atomenergie GmbH, Seibersdorf, Austria). Biophysik, 1: 325-8 (1964). (In German)

Research in radiobiology is reviewed. The various research programs are listed. (M.C.G.)

**27021** CHEMISTRY IN MEDICINE. A Symposium held on the 80th Birthday of Donald Dexter Van Slyke, Brookhaven National Laboratory, Upton, Long Island, New York, March 28-29, 1963. Federation Proc., 23: 585-735 (May-June 1963). (CONF-330)

Three papers presented at this symposium were previously abstracted. One abstract appeared in NSA Vol. 18 as number 19504 and two abstracts appeared in RDA Vol. 8 as numbers 23 and 24. Other papers cover various aspects of biochemical regulation of body functions. (C.H.)

**27022** IN VITRO EVALUATION OF SUSTAINED-RELEASE TABLETS BY DUAL-CHANNEL SCINTILLATION COUNTING. K. O. Montgomery, C. V. Flemming, M. H. Weinswig, R. F. Parke, and H. A. Swartz (Pitman-Moore Co., Indianapolis). J. Pharm. Sci., 53: 340-1 (Mar. 1964).

A rapid procedure was developed for the study of the in vitro release characteristics of radiolabeled drugs in a tertiary drug system. The use of dual-channel scintillation spectroscopy allowed simultaneous determinations of per cent release of each labeled drug from the single sustained-action core tablet. Results are reported for the release characteristics of $^{36}$Cl-labeled phenylephrine hydrochloride and $^{14}$C-labeled aspirin in the presence of chlorpheniramine hydrochloride in vitro from the single sustained-release core tablet. Also described is preparation of the labeled compounds. Chlorine-36-labeled phenylephrine hydrochloride was prepared by dissolving 3 g of compound in distilled water and crystallizing out the free base from the solution rendered alkaline with ammonia. The base was filtered, washed, and dried. Fifty $\mu$C of $^{36}$Cl-labeled hydrochloric acid was then added to a mixture of 1.23 g of the base and 4 ml of distilled water. The solution was neutralized with dilute hydrochloric acid and was later added to the mass during the preparation of the tablet cores. Carbon-14-labeled aspirin was synthesized using 50 $\mu$C of $^{14}$C-labeled acetic anhydride and salicylic acid using routine procedures. The specific activity for the respective compounds were 15 $\mu$C/g for phenylephrine hydrochloride and 45 $\mu$C/g for aspirin. Dissolution of the tablets and sampling and counting procedures are described. The sensitivity of the isotope tracer method allowed use of extremely small samples. In graphically recording drug release it was most convenient to plot the log of the per cent of drug retained vs time. The highest corrected activity was arbitrarily chosen as 100% release. Plots of the release patterns of aspirin and phenylephrine hydrochloride in two media are included, showing that the release in both media assumes typical pseudo-first-order behavior. Thus, this procedure may be useful for studying the rate and re-

liability of release of single tablets at the stage of formulation. (BBB)

**27023** DETERMINATION OF TOTAL BLOOD VOLUME FROM MEASUREMENTS OF TOTAL RED BLOOD CELL MASS AND PLASMA VOLUME, USING SIMULTANEOUSLY INJECTED ISOTOPES. Irwin Berman, Robert Carr, and Edward Malone (Univ. of Miami, Fla.). Nature, 202: 1013-15(June 6, 1964).

A procedure is described for the determination of total blood volume from measurements of total red blood cell mass and plasma volumes using simultaneously injected $^{51}Cr$, as a label for red blood cells, and $^{131}I$, as a label for serum albumin. The contribution of $^{51}Cr$ to the count rate of samples being analyzed for $^{131}I$ was effectively eliminated. (C.H.)

**27024** CALCULATION OF EXPOSURE TIMES FOR SUCCESSIVE AUTORADIOGRAPHS. M. Flinn (London Univ.). Nature, 202: 1036(June 6, 1964).

A rapid method is described for use in calculation of exposure times for the successive specimens of a series of autoradiographs. Curves are presented that may be used for isotopes with various half-life times. (C.H.)

**27025** ELECTROPHORETIC STUDY OF THE PROTEIN FRACTIONS OF THE BLOOD SERUM ON INFECTION WITH BRUCELLOSIS AGENT AND X-RAY IRRADIATION. V. A. Musiiko and I. V. Zaretskaya (Odessa Medical Inst., Academy of Sciences, Ukrainian SSR). Ukr. Biokhim. Zh., 36: 46-51(1964). (In Ukrainian)

An electrophoretic study was made on the blood serum proteins of guinea pigs infected with brucellosis agent, when acting on the organism with a single total irradiation with x rays. The infection of animals with brucellosis agent, as well as irradiation before and after infection caused a considerable fall in the content in the blood of albumins and $\alpha_1$-globulins and a rise in $\alpha_2$-globulins. Previous irradiation followed by infection of the animals with living brucellosis vaccine caused a sharp increase in the gamma globulin content. It may, evidently, be considered that the process of preliminary vaccination before irradiation helps mobilize the defensive forces of the organism, securing a favorable course of the infectious process. (auth)

**27026** VOPROSY RADIOBIOLOGII. SBORNIK TRUDOV. TOM III-IV. (Problems in Radiobiology. Volume III-IV). Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 1-334(1963).

Forty-five papers are included on problems in radiobiology. The effects of external and internal irradiation of blood, hematopoietic system, and central nervous system are discussed as well as infectious processes, immunogenesis, and mitotic processes. The peculiarities of compensatory reactions are analyzed and data are given on radioactivity of bones in humans and animals. Separate abstracts were prepared for 41 papers. (R.V.J.)

*For abstracts of individual papers see: 27027, 27030, 27052, 27053, 27054, 27055, 27173, 27174, 27175, 27176, 27177, 27178, 27179, 27180, 27181, 27182, 27183, 27184, 27185, 27186, 27187, 27188, 27189, 27190, 27191, 27192, 27193, 27194, 27195, 27196, 27197, 27198, 27199, 27200, 27201, 27235, 27236, 27237, 27238, 27239, and 27264.*

**27027** EXAMINATION OF ELECTRIC ACTIVITY OF THE OPTIC NERVE IN VARIOUS FUNCTIONAL STATES. M. A. Allakhverdyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 179-85(1963). (In Russian)

The retinal-optic nerve is a system of a rather complex interrelation. In order to carry out experiments on nervous and pharmacological effects, those of ionizing radiation, etc., in this system it is necessary to have a properly isolated preparation of retinal-optic nerve of the frog with a long-standing bioelectric activity similar to the classic neuromuscular preparation. A description of the procedure to obtain the preparation is given. The potentials of the retinal and optic nerve were measured monopolarily by means of Ag and glass electrodes. These were recorded by photographing them from the screen of a cathode oscillograph ENO-1 using a d-c amplifier. After a long dark adaptation an almost complete disappearance of the off reaction and an intensification of the on reaction were noted. After light adaptation the distribution of the reactions was reversed. (auth)

## Ecology

**27028** (IAN-A-2) INFLUENCIA DE LA COLOCACION DE DOS FERTILIZANTES FOSFATADOS EN LA ABSORCION DE FOSFORO Y EN EL DESARROLLO DE LA CEBADA USANDO EL RADIOISOTOPO P-32. (Effects of Placement and Sources of Phosphate Fertilizers for Barley Using P-32). V. Vega, J. Sanin, and A. C. McClung (Colombia. Instituto de Asuntos Nucleares, Bogota). Jan. 1963. 17p.

Colombian cold climate soils are generally deficient in phosphorus. An experiment was performed on a Bogotá River soil type of clay through the whole profile with pH of 4.6 and poor drainage characteristics. A study was made of efficiency of the placement of concentrated superphosphate and monoammonium phosphate labeled with $^{32}P$ and of the uptake of the phosphorus by barley. The phosphates were applied: by machine in bands below soil surface; by machine in bands on the soil surface; by hand in bands below surface and broadcast. A non-phosphate check was included also. No significant differences in yields were found between phosphorus sources; between band treatments; and between broadcast and check treatments. Significant differences in yield were found between bands and broadcast treatments. Barley plants absorbed phosphorus from soil and fertilizer through growth but they absorbed more phosphorus from fertilizer in early growth stages with a maximum at 30 days. Broadcast and check applications showed differences in phosphorus uptake. (auth)

**27029** A STUDY OF THE DISCRIMINATION FACTOR FOR TRANSFER OF $^{90}Sr$ FROM GRASS TO MILK. Adriana Enda-Marah, O. Paakkola, and D. Merten (Bundesforschungsanstalt für Milchwirtschaft, Kiel). Kiel. Milchwirtsch. Forschungsber., 14: 205-9(1962). (In German)

Data are presented on the content of $^{90}Sr$ in samples of grass and milk collected from various sites in West Germany from April to November 1960. (C.H.)

**27030** BETA-RADIOACTIVITY OF SOME SAMPLES OF ANIMAL BONES, GRASS, AND SOIL. V. O. Ovanesyan, M. L. Arutyunyan, A. A. Mirzoyan, and Ts. A. Amirzadyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 197-200(1963). (In Russian)

A study was made of the comparative radioactivity of bone samples of neat and small cattle, soil, and grass. By means of excluding the potassium background of the ashes of cattle bones, their radioactive contamination may be estimated with a sufficient degree of accuracy. A selective radiochemical analysis was carried out. Radioactive $^{90}Sr$ contamination in the bones of neat and small cattle was detected in most of the samples tested. (auth)

# Metabolism, Tissue Distribution, and Toxicology

**27031** (AEEW-M-391) A NOTE ON THE POTASSIUM CONTENTS OF A GROUP OF 154 PEOPLE IN NORMAL HEALTH. R. G. Speight (United Kingdom Atomic Energy Authority. Reactor Group. Atomic Energy Establishment, Winfrith, Dorset, England). Feb. 1964. 21p.

Estimates were made of the K contents of 154 normal subjects measured with a whole body monitor. The results, together with a brief analysis and correlation with sex, age, weight, and height of the subjects, are presented. (C.H.)

**27032** (ORNL-3601(p.173)) NUCLEIC ACID CHEMISTRY. (Oak Ridge National Lab., Tenn.).

The terminal-deoxynucleotidyl transferase was separated from the replicative-deoxynucleotidyl transferase of calf thymus gland and used to prepare a series of deoxypolynucleotides of completely known sequence, structure, and chain length. Data are presented on the preparation and properties of two series of polymers. (C.H.)

**27033** (UR-637) HIGH SPECIFIC ACTIVITY LABELING OF INSULIN WITH $I^{131}$. Joseph L. Izzo, William F. Bale, Mary Jane Izzo, and Angela Roncone (Rochester, N. Y. Univ. Atomic Energy Project). Feb. 4, 1964. Contract W-7401-eng-49. 25p.

A simple procedure is described for preparing insulin with $^{131}I$ suitable for use in immunoassay techniques of insulin in biological fluids. Iodine-131 produced by fission is used soon after production to minimize the content of $^{127}I$ and $^{129}I$. Hydrogen peroxide which is invariably present in solutions of $^{131}I$ as iodine obtained from Oak Ridge National Laboratory is destroyed by the addition of $Na_2SO_3$ and the excess sulfite in turn oxidized by aeration of the solution at 70°C. By means of a simple jet apparatus, solutions of $^{131}I$ (40 to 80 mC) and of iodine monochloride are added successively to 150 to 250 $\mu$g of insulin in borate buffer of pH 8.0. Chemical exchange produces $^{131}ICl$ which in turn reacts with insulin to label it. Radiation damage is kept small by immediate dilution with a solution of human albumin. Iodine-131 that is not bound to insulin is removed by dialysis. By this method insulin preparations labeled with $^{131}I$ at levels up to 400 mC/mg insulin with efficient use of $^{131}I$ and minimal damage to the hormone as measured by chromato-electrophoresis have been prepared. With slight modification, the technique is also applicable to the radioiodination of glucagon. (auth)

**27034** (ANL-Trans-31) AUTORADIOGRAPHIC STUDY OF THE CONSTANCY OF THE DNA-DOUBLING DURATION IN CELL TYPES OF MOUSE AND RAT BY DOUBLE LABELING WITH H-3 AND C-14-THYMIDINE. Ch. Pilgrim and W. Maurer (Cologne. Universitat. Institut fur Medizinische Isotopenforschung). Translated by Elmar K. Wilip (Argonne National Lab., Ill.). [1964]. 19p.

The duration of the DNA synthesis phase was investigated in 27 cell types of mouse and rat by double labeling with $^3H$- and $^{14}C$-thymidine. Approximately the same duration of S-phase was found for all cell types, the average value being 7.5 hours. This technique applies not only to cell populations which grow asynchronously and under steady state conditions, but also to populations which are subject to diurnal fluctuations of the $^3H$-index, i.e., periodical partial synchronizations. In such cases it is necessary to measure the daily time course of the $^3H$-index. In a number of cell types of the mouse the generation time and the duration of mitosis were also estimated. It is shown that the time interval between the beginning of DNA synthesis and the end of mitosis is relatively constant while the generation times show very great differences. These differences are essentially due to the great variations of the postmitotic-presynthetic resting phase $G_1$. (auth)

**27035** DISTRIBUTION OF RADIO-IODINE STUDIED BY WHOLE-BODY AUTORADIOGRAPHY. S. Ullberg and B. Ewaldsson (Royal Veterinary Coll., Stockholm). Acta Radiol., 2: 24-32(Feb. 1964).

The distribution of $^{131}I$ in mice, rats, and cats was studied by a whole-body autoradiographic technique. Concentration was evident in the choroid plexus, arterial walls, tendons, the cornea, and sclera, and the fetal thymus in addition to the previously known accumulation sites, such as the salivary glands, gastric mucosa, mammary glands, and ovarian follicles. The distribution pattern, compared with that of other halogens and halogenoids studied by the same method, is described. (auth)

**27036** SCINTILLATION DETECTORS FOR DETERMINATION OF CEREBRAL BLOOD FLOW. S. Hedlund, K. Ljunggren, B. Berggren, and P.-O. Brundell (Södersjukhuset, Stockholm and Royal Inst. of Tech., Stockholm). Acta Radiol., 2: 51-64(Feb. 1964).

A method for the determination of cerebral blood flow with three through-flow scintillation detectors connected to counting-ratemeters and a fast recorder is described. Red cells labeled with radioactive chromate ($^{51}Cr$) were for intracarotid and intravenous injections. The resulting dilution curves from the jugular bulbs were evaluated to give cerebral blood flow and various circulation time parameters. These results were compared with those obtained in simultaneous measurements with an earlier established method using red cells labeled with $^{32}P$. No significant discrepancies were found. The influence of various factors on the dilution curves is discussed in some detail. (auth)

**27037** DISTRIBUTION OF RADIOCERIUM AND RADIOPROMETHIUM IN MICE. An Autoradiographic Study. B. Ewaldsson and G. Magnusson (Royal Veterinary Coll., Stockholm). Acta Radiol., 2: 65-72(Feb. 1964).

The distribution patterns of $^{144}Ce$ and $^{147}Pm$ in mice were studied by whole-body autoradiography. Both lanthanides accumulated most in the liver and skeleton. There was also a high uptake of radiocerium by the kidneys, spleen, cartilage, and adrenal cortex and of radiopromethium by the kidneys and cartilage. (auth)

**27038** PLASMATIC ELUTION OF $^{45}Ca$ INJECTED INTO THE RAT, ANALYZED AS A FUNCTION OF SEX AND AGE. J. C. Stoclet and Y. Cohen (Faculte de Pharmacie, Paris). Ann. Nutr. Aliment., 17: 193-205(1963). (In French)

The specific plasma radioactivity of $^{45}Ca$ (15 $\mu$C was administered intraperitoneally to rats) was measured to follow the decrease in activity with time as a function of age, sex, and weight. Four groups were studied: 15 males, 60 days old, 200 g; 9 males, 150 days old, 300 g; 9 females, 90 days old, 175 g; 15 females, 150 days old, 200 g. The $^{45}Ca$ was administered in 0.9% NaCl isotonic solution (0.5 ml), and the animals were sacrificed four, seven, or 16 hr later. Activity of $^{45}Ca$ was determined as oxalate prepared from blood plasma by the method of Patton and Reeder. The following expressions represent the activity for the four groups above, respectively: 60-day males, $2.60e^{-0.084t}$; 150-day males, $9.40e^{-0.125t}$; 90-day females, $6.20e^{-0.109t}$; 150-day females, $11.3e^{-0.067t}$. Values of rapidly exchangeable Ca and the rate of loss of this Ca from the rapidly exchangeable Ca space are expressed for the four lots per

100 g body weight as follows: 60-day males, 38.5 mg, 3.15 mg/hr; 150-day males, 10.6 mg, 1.20 mg/hr; 90-day females, 16.1 mg, 1.75 mg/hr; 150-day females, 8.85 mg, 0.59 mg/hr. The first figure may be related to the rate of growth by the equation Ca = 2.5(rate) + 7. The rate of exchange of $^{45}Ca$ in muscular tissue with plasma is independent of rate of growth and is total in less than four hours. The most important factor in determination of elution of $^{45}Ca$ is not sex or age, but rate of growth. (BBB)

**27039** THE INFLUENCE OF CHELATING AGENTS ON THE DISTRIBUTION OF MERCURY IN THE ORGANISM. V. Nigrovic (Kernforschungszentrum, Karlsruhe, Ger.). Arzneimittel-Forsch., 13: 787-92(1963). (KFK-200). (In German)

The influence of a large number of chelating agents, as well as of isotopic dilution, on the metabolism of $^{203}Hg$ in the rat was studied. All chelating agents were found to reduce the renal deposition of the carrier-free $^{203}Hg$ while the action on other organs or the blood was less marked. Under the influence of certain types of chelating agents the excretion of radiomercury was reduced. Chelating agents with free sulfhydryl groups proved to be superior to all other substances tested. This is particularly true with 2,2′-bis[di(carboxymethyl)amino]diethyldisulfide, 2-mercaptoethyliminodiacetic acid, 2,3-dimercaptopropanol, and D-penicillamine. The influence of the isotope dilution on the distribution of radiomercury was ascribed to the limited capacity of a renal compartment and to the toxic effect of high Hg doses. The theoretical and practical significance of the findings is discussed. (auth)

**27040** THE BIOSYNTHESIS OF $C^{14}$- AND $H^3$-LABELED INSULIN. G. Eric Bauer, Arnold W. Lindall, and Arnold Lazarow (Univ. of Minnesota, Minneapolis and Marine Biological Lab., Woods Hole, Mass.). Atomlight, No. 38, 1-6 (June 1964).

The incorporation of radioactive amino acids into insulin was used to follow insulin synthesis in islet tissue of the goosefish (Lophius piscatorius). Purification of the acid alcohol-soluble protein fraction, using isoelectric precipitation and chromatography, demonstrated the in vitro biosynthesis of insulin. Although the initial steps in insulin synthesis may take place in the microsome fraction, it appeared that the newly synthesized insulin is subsequently transferred to the secretion granule, where it is stored. (C.H.)

**27041** ZONAL SCANNING OF THIN-LAYER CHROMATOGRAMS. Fred Snyder (Oak Ridge Inst. of Nuclear Studies, Tenn.). Atomlight, No. 38, 7-12(June 1964).

Procedures are described for the assay of thin-layer chromatography plates for radioactivity by zonal scanning. Direct counting of the thin-layer adsorbent was carried out in a liquid scintillation system that provided a quantitative and efficient means of counting weak-energy $\beta$ emitters such as tritium and $^{14}C$. High resolution zonal scans were obtained with a device that quantitatively transferred exceedingly small zones into a counting vial. Design features of the zonal scraper are described and illustrated and examples using palmitic-1-$^{14}C$ as a tracer of lipid metabolism in rat liver or bone marrow are included. Advantages of the method over other assay techniques are discussed. (C.H.)

**27042** A STUDY OF THE MECHANISM OF PHOSPHATE TRANSPORT IN SEA URCHIN EGGS BY ION-EXCHANGE ANALYSIS OF RAPIDLY LABELED COMPOUNDS. W. M. Griffiths and A. H. Whiteley (Univ. of Washington, Seattle). Biol. Bull., 126: 69-82(Feb. 1964).

Incorporation of $^{32}P$ into various components of fertilized sea urchin eggs was studied by exposing eggs to pulses of $^{32}P$. The radioactive compounds formed were identified by ion-exchange and paper chromatography. Control eggs of Strongylocentrotus purpuratus at the two-cell stage incorporated 6.4 to 39.1% of the $^{32}P$ from sea water in 10 sec to 10 min; most of this (98.4% for a one-min pulse, and 94.5% for a 10-min pulse) was in perchloric acid-soluble compounds. Distribution of $^{32}P$ after one-min and 10-min pulses was similar. In a representative one-min experiment 27.0% was found in arginine phosphate; 7.7% in inorganic phosphate; 0.8% in glucose-6-phosphate; 2.0% in ATP; and 5.7% was distributed among five unidentified fractions. Glucose-1-phosphate, while present in the extract, was not labeled. In the presence of $5 \times 10^{-3}$M Na azide, or $10^{-4}$M K cyanide, the incorporation of $^{32}P$ was as much or more than in the controls, but its distribution was greatly altered. In the presence of azide, incorporation into arginine phosphate was reduced to 1.2% and into ATP to 14.3% while inorganic phosphate increased to 76.9%: a decrease of 65.2% in high-energy phosphates and an increase of 69.2% in inorganic phosphate. Similar, but much less marked, changes were produced by 0.1M monoiodoacetate. The results are incompatible with any mechanism for transport involving the initial formation of high-energy phosphate, but are compatible with a carrier-type of transport which would release inorganic phosphate unchanged into the metabolic pool in the eggs. (BBB)

**27043** THE ENRICHMENT OF POTASSIUM AND CESIUM IN ERYTHROCYTES. E. Oberhausen, K. Pfleger, and W. Forth (Universität, Saarlandes, Ger.). Biophysik, 1: 373(1964). (In German)

The uptake and release of potassium and cesium by rabbit erythrocytes were investigated. Measurements of uptake showed that potassium is incorporated in the erythrocytes 4.5 times faster than cesium. Measurements of release showed that potassium is decorporated about 1.5 times faster than cesium. Measurements on human erythrocytes gave the same ratios. (M.C.G.)

**27044** METHOD IMPROVEMENT FOR IRON METABOLISM INVESTIGATIONS WITH RADIOIRON ($^{59}Fe$)- AND RADIOCHROMIUM ($^{51}Cr$)-LABELED ERYTHROCYTES. E. H. Graul, G. Hagemann, H. Hundeshagen, and H. Kuni (Philipps-Universität, Marburg, Ger.). Biophysik, 2: 42-55(1964). (In German)

A formula was derived for erythropoiesis and the erythroblast iron pool was calculated for use in studies of iron metabolism by erythrocytes labeled with $^{51}Cr$ and $^{59}Fe$. $^{51}Cr$ was used to determine blood volume and erythrocyte life. Measurement methods were improved so that only 0.1 ml of blood was needed for each study. Results using this method are compared with other methods. (M.C.G.)

**27045** AUTORADIOGRAPHIC STUDIES ON THE INCORPORATION OF THYMIDINE-$^3H$, URIDINE-$^3H$, AND PHENYLALANINE-$^3H$ IN THE CHLOROPLASTS OF CLIVIA MINIATA AND BILBERGIA SP. M. J. Olszewska and E. Mikulska (Univ. of Lodz, Poland). Experientia, 20: 267-8(1964). (In French)

Mature chloroplasts of Clivia miniata and Bilbergia sp. showed intensive incorporation of thymidine-$^3H$ into DNA and uridine-$^3H$ into RNA. But phenylalanine-$^3H$ was mostly incorporated in the proplastids. (auth)

**27046** PLACENTAL TRANSFER OF $^{131}I$-LABELED IODIDE IN THE GUINEA PIG. W. T. London, W. L. Money, and R. W. Rawson (Sloan-Kettering Inst., New York). J. Endocrinol., 28: 247-52(Feb. 1964).

Studies were conducted by perfusing the guinea pig placenta in situ with the fetus removed from the system, thereby allowing direct measurement of transfer of $^{131}I$ from the maternal to fetal and fetal to maternal sides of the placenta. By adding stable iodide or thiocyanate to either the maternal circulation or the fetal side of the placenta, the influences of these substances on transfer were determined. These studies confirmed that radioactive iodide administered to the mother concentrates on the fetal side of the placenta and that iodide passes poorly from the fetal to the maternal side of the placenta. Also, $^{131}I$ appears to be concentrated against a gradient on the fetal side of the placenta, as seen in recirculation studies. The previously observed failure of graded nontoxic levels of $^{127}I$ in the perfusate to inhibit the transfer of radioiodide from mother to fetus supports the concept of an active type of transport. It was shown that the accumulation of radioiodine by the thyroid in the normal fetal guinea pig can be prevented by prior treatment of the pregnant mother with sodium iodide ($^{127}I$). Such treatment, however, does not alter the transfer of $^{131}I$ from the maternal circulation to fetal blood. Thus the fetal placenta concentrates radioiodide to a greater extent than does the maternal portion of the placenta. The relative differential between the concentration of $^{131}I$ in maternal and fetal placentas is, however, roughly the same as that between maternal and fetal plasma. Nevertheless, the $^{131}I$ in the maternal placenta was usually two to four times higher per unit weight than in maternal plasma, and the same was true of fetal placenta compared with plasma. In neither case could the placental radioactivity be accounted for by the remaining blood content. Hence, it is clear that the placenta shares the ability to concentrate iodide along with the thyroid, mammary, salivary, and gastric glands. There was no evidence that placenta can form organically bound iodine, although the actions of thiocyanate which both blocked the accumulation of iodide, and discharged it from the placenta, are similar to the action of thiocyanate on the thyroid. (BBB)

**27047** DISTRIBUTION OF $^{144}Ce$ IN THE SUBCELLULAR FRACTIONS OF THE RAT LIVER. P. F. Periti and M. Hansmann (Institut für Strahlenbiologie, Kernforschungszentrum, Karlsruhe, Ger.). Minerva Nucl., 8: 37-9(Jan.-Feb. 1964). (In Italian)

The time relationships of the distribution of $^{144}Ce$ in the various subcellular fractions of the rat liver were investigated. For theoretical interpretation of the experimental data on the basis of the compartment theory, a mammillary, closed four-compartment system was chosen as a model of kinetic distribution. A system of four linear differential equations with constant coefficients was derived from this model and the corresponding transfer constants were calculated. The system was solved by means of a digital computer. (auth)

**27048** INVESTIGATION ON IN VITRO INCORPORATION OF $^{86}Rb$ BY PART OF THE ERYTHROCYTES IN THE NEPHROTIC CHILD. G. C. Mussa, A. Balocco, and L. Mosso (Università, Turin). Minerva Pediat., 15: 270-5 (Mar. 3, 1963). (In Italian)

Capture of $^{86}Rb$ by erythrocytes of nephrotic patients was studied in vitro as a model for patients in the acute phase not yet subjected to proper therapy and in the same patients in the course of prednisone treatment. The method followed was that of Henegar, Friskey, and Preston; patients were fasted 6 hr before a 5-ml sample of blood was removed. The results were expressed as percent capture of $^{86}Rb$. Fourteen normal subjects, aged two to 12 (weight 13 to 36.5 kg), had maximum 48%, minimum 38%, mean 43.2%, with no trend relative to age or weight. Ten nephrotic patients, aged two to 12 (weight 12 to 28.5) had maximum 60.7%, minimum 49.1%, mean 52.24% or 20.9% above normal, with no trend relative to age or weight, before treatment. The same patients after treatment had maximum 47.3%, minimum 36.8%, mean 40.9% or 5.3% below normal with no trend relative to age or weight. These results are in agreement with previous ones if the system is used as a model for K capture. That is, there is a marked reduction of intracellular K in the nephrotic patient. (BBB)

**27049** MEASUREMENT OF THE IN VIVO DEGRADATION OF CARBON-14 LABELLED THYMIDINE AND ITS HALOGENATED ANALOGUES IN MAN BY CONTINUOUS MONITORING OF EXPIRED CARBON-14–CARBON DIOXIDE. Joseph P. Kriss, Richard K. Shaw, Robert Loevinger, and Nikki Edmunds (Stanford Univ., Palo Alto, Calif.). Nature, 202: 1021(June 6, 1964).

A rapid and convenient method is described for measurement of the degradation of $^{14}C$-labeled thymidine and its halogenated analogs in man by continuous monitoring of expired $^{14}CO_2$. (C.H.)

**27050** NUTRITIONAL IMPLICATIONS OF THE WHOLE-BODY COUNTER. Nutr. Rev., 21: 321-4(Nov. 1963).

Application of whole-body counters in nutritional studies in man are discussed. Emphasis is placed on the use of naturally occurring $^{40}K$ in studies of K metabolism, long-term studies of K balance and lean-body-mass and K/N ratios in normal and obese persons. (C.H.)

**27051** ON THE REMOVAL OF INCORPORATED STRONTIUM ISOTOPES IN EXPERIMENTAL ANIMALS. THEORETICAL PRINCIPLES OF THE DECORPORATION TECHNIQUES WITH SOME EXPERIMENTAL RESULTS. Kai Setaelae, Bijoern Lindroos, and Aarre O. Kuikka (Univ. of Helsinki). Strahlentherapie, 123: 545-62(Apr. 1964). (In German)

The homeostatic aspects of Sr in the organism are reviewed. It was concluded that there exist no adequate experimental data justifying the description of the behavior of Sr as "irreversibly incorporated into the skeleton." Some biologic and physico-chemical premises for a withdrawal technique are outlined. Instead of the renal regulatory and excretory system of the mineral/fluid balance (kidneys: glomerular ultrafiltration, and tubular reabsorption, respectively), the extrarenal regulatory and excretory system of the mineral/fluid balance (salivary and skin glands as well as the excretory glands of the mucous membrane of the large intestine: ordinary cell activity) is utilized. Advantages include profiting from certain normal biological functions and systems without altering their nature or without compelling them into new, anomalous activities that they have not previously performed. When instilled to experimental animals (cats and mice), neither stable Sr nor radioactive Sr ($^{85}Sr$ + $^{89}Sr$) was irreversibly incorporated into the skeleton. By administration of pilocarpine nitrate it was possible to transfer Sr ions from one tissue compartment to another within relatively wide limits. It was further possible to detect highly significant quantities of Sr in artificially provoked excretion even after a long period of time after instillation of the isotope, 215 days by mice, 51 days by cats. The Sr concentration in the departed saliva was hypertonic when compared with the Sr concentration in the blood, whereas the concentration of Ca was hypotonic. Further, the total quantity of saliva that could be removed without risks during an experimental period of 2 months (in experiments with mice) was in several cases up to 50% of the body

weight of the experimental animal. The following facts indicate the reliability of the results: simple experimental techniques, sufficiently large experimental materials, different kinds of parallel experiments, and consistent results from repeated experiments. (auth)

**27052** ELECTROPHORETIC STUDY OF PROTEIN COMPOSITION OF THE BLOOD SERUM IN IMMUNIZED RABBITS. M. O. Pogosyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 141-4(1963). (In Russian)

A study was made of certain changes in the general protein composition, fractional composition of proteins and the serum agglutinin titer of the blood serum of immunized rabbits. The data showed an increase of the general protein and a rise of globulin level at the expense of the gamma fraction, along with high titers of agglutinins. (auth)

**27053** ON RADIOACTIVITY OF THE SKELETON OF NEW-BORN CHILDREN. M. L. Arutyunyan, V. A. Akopova, and V. O. Ovanesyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 201-4(1963). (In Russian)

Beta radiation in the bones of children born in Yerevan in 1960 is reported to have been observed in six cases. A skeletontopically diverse distribution of $\beta$ radiation was noted. The $\beta$ radiation revealed in the skeleton of newborn children was reported to be of the order of $10^{-8}$, $10^{-11}$, $10^{-10}$ C. Specific $\beta$ radioactivity prevailed both in the shoulder girdle and in the skull bones where specific $\beta$ radioactivity/kg of crude weight was on the average of the order of $10^{-9}$, and in certain bones it amounted to $10^{-8}$. (auth)

**27054** RADIOACTIVE IODINE (I-131) USED TO DETERMINE HORMONAL ACTIVITY OF THE THYROID OF RATS AFTER CASTRATION. A. A. Baiburtsyan, V. A. Airumyan, G. A. Kazaryan, R. R. Arutyunyan, S. A. Nazinyan, and V. M. Arutyunyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 225-8(1963). (In Russian)

The thyroid activity in 39 rats was determined by means of radioactive I after castration. Castration was carried out by two procedures: in one the testicles and epididymis were removed, and by the new one in which a portion of the parenchyma was removed without damaging the membrane and epididymis. It was shown that the new method of castration slightly reduced the thyroid hormonal activity until the 7th day after castration, with the subsequent compensation of its hormonal function, which was revealed by the normal absorption of radioactive I in 15, 30, 45, and 60 days, following castration. By the previous method the thyroid function was abruptly depressed, which was evident by a low absorption of radioactive I on the same dates of the investigation. (auth)

**27055** SOME DATA CONCERNING EFFECT OF COLAMINE ON DEVELOPMENT OF VACCINE VIRUS AND FORMATION OF ANTIVACCINE IMMUNITY. G. V. Kamalyan, L. A. Kamalyan, R. A. Ter-pogosyan, Zh. Ts. Vartevanyan, and A. T. Ter-avetisyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 283-7 (1963). (In Russian)

Colamine at doses of 0.001 to 10.0 mg had no injurious effect on the chicken embryo and on the properties of virus in vitro. The introduction of colamine into the embryo increased reproduction of vaccine virus. Systematic injection of colamine to vaccinated rabbits caused an increase of the titers of antibodies. (auth)

**27056** ON THE REACTION OF CARBONATE HYDROLASE IN HEAVY WATER ($D_2O$). Manfred Lieflaender (Max-Planck-Gesellschaft, Goettingen, Ger.). Z. Physiol. Chem., 333: 159-61(Oct. 1963). (In German)

The rate of the reaction $CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$ as catalyzed by carbonate hydrolase (carbonic anhydrase) was compared in $H_2O$ and $D_2O$. The rate of the enzymic hydration of $CO_2$ was lower in $D_2O$ than $H_2O$, whereas the rate of the reverse reaction was the same in the two media. In a system composed of 20 $\mu$g of enzyme/ml of $H_2O$ or $D_2O$, the $H_2O$ hydration reaction required 10 sec, compared with 28 sec with $D_2O$. Although it is conceivable that $D_2O$ might effect the native protein structure of the enzyme, this does not appear to be the case here since the reverse reaction is not affected by $D_2O$. It is more likely that $D_2O$ acts on the active site of the enzyme in the hydration reaction. A reaction seqtence for hydration of $CO_2$ is proposed whereby the first step involves the splitting of water at neutral pH to a proton and hydroxyl ion, the proton being taken up by the imidazolyl group at the active center of the enzyme. The known isotope effect of imidazole ($k_{HOH}/k_{DOD}$ = 2 to 3) in base catalysis would explain the results. Nucleophilic catalysis with imidazole shows no isotope effect. (BBB)

**27057** ON THE INFLUENCE OF VITAMIN $D_3$ ON $^{90}Sr$ METABOLISM. Berthold Schmidt (Johannes-Guteberg Universität, Mainz). Z. Ernaehrungswiss., 4: 173-8(Feb. 1964). (In German)

The influence of vitamin $D_3$ on $^{90}Sr$ metabolism was studied on growing female rats (30 to 40 g), divided into four groups: a control group without enriched diet; a group with 50 I.U. vitamin $D_3$ per day; a third with 500 I.U.; a fourth with 5000 I.U. The $^{90}Sr$ contamination was 1750 pC $^{90}Sr$/g Ca. The activity found in the blood plasma reached a maximum of 800 pC/g Ca for group two in 50 days; 1600 for group three in 30 days; 2600 for group four in 30 days; and then decreased. Activity in urine reached a maximum of 2200 for group two in 15 to 20 days; 1900 for group three in 25 days; 1300 for group four in 20 days. The values decreased for the first two groups thereafter and stayed constant for the last. Skeletal activity reached a maximum of 450 to 550 pC/g Ca (value for group four > three > two) in 70 days and decreased slightly; the controls were slightly less active, 425 at 100 days being maximum. The ratios, or discrimination factors, of (plasma/feed), (urine/plasma), (skeleton/feed), and (skeleton/plasma), determined on 120 g animals, were 0.38, 3.1, 0.21, and 0.56, respectively, for controls; for the 5000 I.U. group, these values were 1.0, 0.71, 0.30, and 0.29. The animals with smaller vitamin doses had intermediate values. Thus administration of vitamin $D_3$ improves the discrimination in the plasma/skeletal transition, but discrimination in the resorption and plasma/urine ratios is lessened by this treatment. (BBB)

**27058** STUDIES ON THE INFLUENCE OF INSULIN ON RENAL $^{131}I$ EXCRETION. Siegfried Heller and Guenther Hillmann (Universität, Tuebingen, Ger.). Z. Ges. Exptl. Med., 134: 493-7(1961). (In German)

Rabbits and rats were injected subcutaneously with $^{131}I$ (30 and 70 $\mu$C, respectively) and insulin (0.3 and 0.5 units), and urinary excretion of $^{131}I$, Cl, and water was followed for 6 hr. In rabbits, by the first postinjection hr insulin had increased the excretion of $^{131}I$ 2.3 times. Insulin also induced diuresis in the rabbit but this occurred the second hr, so that this enhanced $^{131}I$ excretion was independent of the diuretic effect. Since the insulin preparation used contained small amounts of glucagon, pure glucagon was injected to examine its possible influence. It did not alter urinary $^{131}I$ excretion when injected in 20-$\mu$g doses. In rats similar effects were observed. Thus, injection of 0.5 unit of insulin increased urinary $^{131}I$ excretion 100% during the

first 6 hr while urine volume rose only 52% over this period. It was demonstrated that insulin did not appreciably affect uptake of $^{131}I$ by the thyroid gland and it increased serum protein-bound $^{131}I$ only slightly, indicating that these factors are not implicated in the insulin-induced increase in $^{131}I$ excretion. Chloride excretion was also enhanced by insulin but not to the extent seen with $^{131}I$. (BBB)

**27059** ENZYMATIC CONVERSIONS IN TRITIUM WATER. II. THE FORMATION OF T-LABELED FUMARIC ACID. Theodor Guenther and Martin Wenzel (Freie Universität, Berlin). Z. Physiol. Chem., 335: 63-8(1963). (In German)

The incorporation of $^3H$ into organic acids through the use of fumarate hydrogenase was studied, using the method of Wenzel and Guenther. Fumarate hydrogenase in crystalline form produced active malate from fumarate and $H^3HO$. Malate activity was 0.63 $\mu C/\mu mole$; activity of recovered fumarate was 0.077 $\mu C/\mu mole$. The low incorporation of $^3H$ in recovered fumarate indicates a stereospecific enzymatic step. When the reaction was repeated in the presence of pyruvate, nicotinamide adenine dinucleotide, malate dehydrogenase, and lactate dehydrogenase, the malate produced had activity 0.99 $\mu C/\mu mole$, fumarate 0.51 $\mu C/\mu mole$, lactate 0.59 $\mu C/\mu mole$. The activity of $H^3HO$ in both experiments was 0.77 $\mu C/\mu g$-atom H. This was compared with a similar experiment using noncrystalline enzyme preparation in which the product activity was: malate, 0.93; fumarate, 0.37; lactate, 0.64 $\mu C/\mu mole$, from $H^3HO$ activity 0.89 $\mu C/\mu g$-atom H. A mechanism is discussed for the specificity of this reaction. Evidence was gained for the suggested mechanism by the increase in labeled fumarate when oxalacetate was added to the reaction mixture; in this case, malate activity was 0.69 and fumarate activity was 0.25 $\mu C/\mu mole$ from water activity 0.69 $\mu C/\mu$-atom H. In the presence of dithionite under anaerobic conditions, malate activity was 0.67 and fumarate, 0.04 $\mu C/\mu mole$ from water activity 0.69 $\mu C/\mu g$-atom H. Radiochromatograms are illustrated. (BBB)

**27060** METABOLIC EFFECTS AND METABOLISM OF SELENIUM IN ANIMALS. Irene Rosenfeld. Agricultural Experiment Station Bulletin 414. Laramie, Wyo., University of Wyoming, [1964]. 64p.

Results are reported from a series of studies on Se metabolism in rats and sheep, in which $^{75}Se$ was used as tracer. The metabolic interferences produced by Se in animals were investigated using $^{31}P$ and $^{32}P$ distribution in liver and other tissues as the criteria. The effects of Cu, Zn, and U on chronic selenosis were also studied. (C.H.)

## Radiation Effects

**27061** (COO-965-21) THE EFFECTS OF X-RADIATION ON PLATEAUED POPULATIONS OF TRIBOLIUM CASTANEUM IN REGARDS TO REPRODUCTIVE FITNESS AND RESPONSE TO SELECTION. Final Report. A. Earl Bell (Purdue Univ., Lafayette, Ind. Population Genetics Inst.). May 29, 1964. Contract AT(11-1)-965. 8p.

Results are summarized from a series of studies on the effects of various levels of x radiation on the response to selection in plateaued population of the flour beetle, Tribolium castaneum. The response of the plateaued population was compared with that of unselected base populations exposed to the same levels of radiation and selection intensity as to reproductive fitness and inheritance of qualitative genes or chromosome aberrations. A list is included of publications resulting from this study. (C.H.)

**27062** (NYO-1680-1) FINAL REPORT [ON VASCULAR PROBLEM FOLLOWING WHOLE-BODY X-IRRADIATION], OCTOBER 1953–MAY 1964. (New York Univ., New York. Medical Center). Contract AT(30-1)-1680. 39p.

Progress is reported on studies of vascular problems in mammals following whole-body x irradiation. Data are presented on the effects of radiation on peripheral vascular beds, effects on parenchymatous organs such as adrenal glands, liver, spleen, and kidney, the initiation of radiation damage to capillaries and larger blood vessels, the effect of shock, and fundamental processes involved in radioinduced hemorrhage in rats, mice, and rabbits. Data are included from studies on radiation effects on blood vessels in pregnant rats as a means of establishing alterations in developing rats in utero; radiation effects on metabolic activity and enzyme systems that may be related to vascular physiology; and radiation effects on enzyme systems in gametes and developmental stages of both vertebrate and invertebrate marine organisms including Fundulus, starfish, mollusks, and annelids. It was concluded that the radioinduced vascular defects is made up of two separate components and that despite the fact that the hemostatic defect develops at the same time as thrombocytopenia and leucopenia, it cannot be ascribed to the absence of these blood elements directly. A list is included of publications resulting from this study. (C.H.)

**27063** (NYO-2737-1) INCREASED STABILITY OF TEMPLATES FOR SOME ENZYMES OF DNA SYNTHESIS IN TUMORS; DEOXYCYTIDYLATE DEAMINASE, THYMIDINE AND THYMIDYLATE KINASE. Final Report. Jay S. Roth (Connecticut. Univ., Storrs). [1964]. Contract AT (30-1)-2737. 11p.

Progress is reported in studies on the relation of certain enzymes to the proliferation rate of cells. The enzymes studied include deoxycytidylate deaminase, thymidine kinase, and thymidylate kinase. It is pointed out that these enzymes exhibit high activity in rapidly proliferating tissues such as tumors, regenerating liver, and embryonic tissue and little or no activity in non-growing tissue such as adult liver. Results are reported from studies on the effects of $\gamma$ radiation on enzyme activities in chick embryos, and rat regenerating liver, thymus, and hepatomas. The effect of actinomycin on deoxycytidylate deaminase activity in rat hepatoma and thymus was also measured. Results indicate that the alteration of DNA by radiation or actinomycin treatment leads to a cessation of production of messenger RNA for these enzymes and is followed by a decline in their activity. (C.H.)

**27064** (ORNL-3601(p.92-7)) RADIATION MICROBIOLOGY. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on the effects of DNA content on the radioresistance of Escherichia coli; the influence of environmental conditions on the oxygen effect in x irradiated E. coli; the genetic nature of cell division and radiosensitivity of E. coli; the effects of nitrogen mustard on growth and division of E. coli; and chromosome aberrations associated with mutations to bacteriophage resistance in E. coli. (C.H.)

**27065** (ORNL-3601(p.98-104)) RADIATION IMMUNOLOGY. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies of the effects of growth and senescence on the primary antibody-forming potential of mouse spleen; the mechanism for enzyme action and its relevance to differences between antibodies and enzymes; the kinetics of antibody production by mouse spleen cells in culture; the destruction of erythrocyte antigens by peritoneal phagocytic cells; the suppression of the appearance of antibody-forming cells in the spleen of mice and rabbits

with supraoptimal doses of antigen; the fate of rat thoracic duct lymphocytes in culture after antigenic stimulation; and cellular changes during embryonic splenomegaly. (C.H.)

**27066** (ORNL-3601(p.105-9)) TISSUE CULTURE. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on the frequency of x-ray-induced chromatid aberrations in Vicia faba root cells at different time of the cell cycle; morphological alteration of small lymphocytes in human leukocyte cultures; and aberrations induced in human leukocytes by 2.5-Mev neutrons. (C.H.)

**27067** (ORNL-3601(p.110-15)) AEC-NASA SPACE BIOLOGY PROGRAM. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on the relative biological effectiveness of 22 Mev to 750 Mev protons using a number of biological test systems. The energies used cover most of the important energy range in the Van Allen radiation belts and, to some extent, the expected energies from solar flares that may be encountered during space flight. Data are presented on the inactivation of heterokaryotic conidia of Neurospora by 250 kvp x rays, 430-Mev protons, and 730-Mev protons; mutations in Neurospora induced by 250-kvp x rays and 430-Mev protons; inactivation and mutation induction in Escherichia coli by protons of various energies, x radiation, and 100-Mev carbon ions; the production of chromosome aberrations in human white blood cells by 430-Mev protons, 130-Mev protons, and 250-kvp x rays; and the inactivation of mouse spermatogonia and oocytes by x rays and 130-Mev protons. The design, fabrication, and testing of a device for blood irradiation experiments for the Gemini-III manned space flight are described. (C.H.)

**27068** (ORNL-3601(p.128-45)) PATHOLOGY AND PHYSIOLOGY. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on the pathological and physiological effects of radiation in mammals. Results are reported from studies of late somatic effects in mice of the radiomimetic chemical 4(p-dimethylaminostyryl)-quinoline; the influence of radiation dose, partial-body shielding, and AET on the induction of glomerulosclerosis in mice; attempts to isolate and identify the virus responsible for the transmission of radioinduced myeloid leukemia in mice; chromosome abnormality in mice with radioinduced myeloid leukemia; tracer studies of the survival of rat blood platelets; the lymphocyte content and proliferative capacity of serially transplanted mouse bone marrow in irradiated recipients; the isolation of small, lymphocyte-like mononucleated cells from mouse bone marrow; the resistance of hybrid mice to growth of transplanted parental bone marrow; the survival of x irradiated germ-free mice; and the generation time of duodenal crypt cells in normal and germ-free mice. (C.H.)

**27069** (RTD-TDR-63-3011) COMPARISON OF MORTALITY OF RATS FOLLOWING PARTIAL AND WHOLE-BODY EXPOSURE TO 250-KVP X-RAYS. Ronald E. Engel (Air Force Weapons Lab., Kirtland AFB, N. Mex.). Jan. 1964. 17p. (AD-428811)

Forty-one adult rats were exposed to 3000 r regional x irradiation from a 250-kvp source. Regional irradiation consisted of whole-body, head-shielded, and head-only, utilizing a specially built restraining apparatus for partial body irradiation. Rats exposed to the whole-body and head-shielded irradiation died at an average of 3.8 and 4.0 days post-exposure respectively. Rats exposed to the head-only irradiation died at an average of 15 days post-exposure; this group exhibited the largest weight loss of all irradiated groups. (auth)

**27070** (TID-20708(p.28-41)) RADIATION BOTANY. Carl C. Moh and Juan J. Alan (Inter-American Inst. of Agricultural Sciences, Turrialba, Costa Rica).

Progress is reported in studies of radiation botany. Data are presented on the radiosensitivity of several tropical plant species including Pinus species, cocoanut (Cocos nucifera), rubber (Hevea brasiliensis), mahogany (Swietenia humilis), and a comparative study on the biological response of beans (Phaseolus vulgaris) to acute and chronic $\gamma$ radiation. (C.H.)

**27071** (TID-20708(p.51-71)) STERILIZATION OF THE MEDITERRANEAN FRUIT FLY AND ITS APPLICATION TO FLY ERADICATION. Kamta P. Katiyar and Julio Valerio (Inter-American Inst. of Agricultural Sciences, Turrialba, Costa Rica).

Progress is reported in studies on the eradication of the Mediterranean fruit fly by release of irradiated males. Data are presented on the effect of exposure of the pupal stage to various doses of $\gamma$ radiation on the sexual vigor of male flies, the mating behavior of the flies, the effects of single- and multi-mating of females on the egg hatch, effects of alternate matings with normal and sterile males on the fertility of females, the effects of cage size on fertility, and results of field tests after the release of $^{32}P$-labeled adults. Data are included from studies on the biology and control of the tropical warble fly (Dermatobia hominis), an insect whose larval stage is parasitic on cattle and results in valueless hides. (C.H.)

**27072** INFLUENCE OF $\gamma$ RADIATION OF $^{60}Co$ ON RED BLOOD CELLS OF HUMAN BANK BLOOD. Tadeusz Dorobisz, Stanislaw Przestalski, Michal Masiak, Edward Bielinski, and Andrzej Gradzinski. Acta Physiol. Polon., 25: 85-92(Jan.-Feb. 1964). (In Polish)

Human bank blood was submitted to doses of $2 \times 10^5$ r of $\gamma$ rays and was then stored for four weeks. Significant differences in the penetration of phosphate ions into the red blood cells of irradiated and control blood, hemoglobin content or hematocrit indexes were not observed. In irradiated blood a slight shift in pH toward the alkaline side and somewhat lower values of $PCO_2$ were found. After eight days osmotic resistance of the red blood cells of irradiated blood showed complete breakdown, accompanied by marked hemolysis. The most interesting observation is that the plasma K levels of irradiated blood increased sevenfold 24 hr after irradiation, but further elevation did not occur. In control blood after eight days the K levels were two times higher than initially, and after four weeks, four times. Sodium levels were lowered in the plasma of both groups of blood in parallel to the elevation of K levels. Inorganic P was increased in proportion to degree of hemolysis, especially in irradiated blood. (auth)

**27073** AN INVESTIGATION OF POSSIBLE GENETIC DAMAGE IN THE OFFSPRING OF WOMEN RECEIVING MULTIPLE DIAGNOSTIC PELVIC X RAYS. Diane Wilson Cox (Hospital for Sick Children, Toronto). Am. J. Human Genetics, 16: 214-30(June 1964).

Women exposed to multiple diagnostic pelvic x rays during the treatment in childhood of congenital dislocation of the hip were investigated. Their offspring were compared with those of the probands' sibs for indications of radiation damage. Comparisons with data from the Province of Ontario were made when possible. The frequencies of stillbirths, infant deaths, and abortions were similar for the irradiated mothers and controls. The proportion of males tended to be lower among the offspring of probands than among offspring of controls. The frequency of abnormal

offspring was significantly higher among the exposed mothers. The mean birth weights of offspring, particularly males, appeared to be lower for the offspring of exposed mothers than of controls. The possibility of genetic damage from radiation is discussed. (auth)

**27074** CONTRIBUTION TO THE STUDY OF THE INFLUENCE OF IRRADIATION ON THE NUCLEUS HABENULAE AND THE PINEAL GLAND. R. Miline, R. Werner, M. Scepovic, V. Devecerski, and R. Krstic (Medical School, Novi Sad, Yugoslavia). Ann. Endocrinol. (Paris), 24: 380-4 (Mar.-Apr. 1963). (In French)

Rats that received 800 r of whole-body x irradiation, and were sacrificed after a period varying from 4 to 9 days, showed changes of a progressive nature in the habenulo-epiphysial system, such as hypertrophy of nuclei and nucleoli of neuroganglion cells of the internal nucleus of the habenula and hypertrophy and hyperplasia of the pineocytes with hypertrophy of their nucleoli and increased numbers of intranuclear structures. In rats that received 600-r irradiation, and were sacrificed 8 to 10 weeks after irradiation, involutive changes were found both in the internal nucleus of the habenula and in the pineal gland. The part played by the habenulo-epiphysial system in radiation syndrome is discussed. Hypertrophy of this system reflects a reaction to stress whereby activity of the system is stimulated at early periods after irradiation. Later the system undergoes involution among the survivors of 600-r irradiation. The postirradiation changes in the cells of this system resemble those occurring in the adrenal cortex and thyroid gland after irradiation, which also react to this stress by hypertrophy and later involution. It is suggested that the secretory products of the pineal gland act to oppose the catabolic effects of radiation stress. The late depression of the gland's activity can be considered on adaptation phenomenon, seen also in other stress situations. (BBB)

**27075** CHROMOSOMAL ANALYSIS OF CANCER CELLS AND OF BONE MARROW AND BLOOD CELLS IRRADIATED IN VITRO. J. de Grouchy, G. Vallee, C. Nava, and Maurice Lamy (Institut National d'Hygiene, Paris). Ann. Genet., 6: 9-20(1963). (In French)

Chromosome analysis was conducted on cells cultured from an ovarian cyst, an ovarian carcinoma, and a breast adenocarcinoma. An abnormal chromosome, acrocentric of the size of chromosomes 4 to 5 and called K1 was present in all the cells from the ovarian cyst, most often in the disomic state, and in 30% of the cells from the ovarian carcinoma. An abnormal chromosome, subtelocentric, larger than chromosome 1 was present in all cells from the breast cancer; it was named K2. Two modes were noted in the distribution of the chromosome numbers, one paradiploid at 45, 48, and 40, respectively, in the three cancers, the other hypotetraploid at 88 to 90 and 52 to 62, respectively, in the two ovarian cancers. Hypotetraploid cells are rare in the breast cancer. Bone marrow cells and peripheral blood leucocytes, obtained from individuals with a normal karyotype were irradiated immediately after the medullary or venous punctures at increasing x-ray doses from 100 to 300 r. After three and four days in culture, chromosome analysis showed that, at equal doses, marrow cells exhibit fewer chromosome rearrangements than peripheral blood leucocytes. Respective frequencies of total aberrations varied in a linear fashion from 23.8 and 27.6% at 100 r, to 71.2 and 79.9% at 300 r. The observed chromosome rearrangements resemble aberrations observed by others, namely polyploidy, dicentrics, ring chromosomes, as well as K1 and K2 types of rearrangements. These results are discussed with regard to the chromosome theory of carcinogenesis. Two hypotheses are considered: in the first, chromosome rearrangements are an epiphenomenon of carcinogenesis, as well as an independent consequence of known carcinogenic factors, namely, certain viruses, ionizing radiations, and carcinogenic chemicals. In the second hypothesis, chromosome rearrangements are considered as the common pathway for these carcinogenic factors, and, thus, become the ultimate cause of carcinogenesis. The second hypothesis is considered as more likely. (BBB)

**27076** CERTAIN ENVIRONMENTAL CONDITIONS AND HEMATOLOGICAL DISORDERS. Farid L. Haurani and L. M. Tocantins (Jefferson Medical Coll., Philadelphia). Arch. Environ. Health, 8: 778-804(June 1964).

The interrelationships between environmental conditions and hematological disorders are reviewed with emphasis on the effects of radiation, high altitudes, and nutrition. The discussion on radiation effects is limited to effects on the hematopoietic system. It is pointed out that the response is a function of the type of radiation, dose of radiation, tissue sensitivity, and animal species or strain. The more penetrating the radiation the more profound are the changes manifest in blood, and the degree and effect of radioactive elements on hematopoiesis are related to the localization and amount of these elements in or near bone marrow tissues. The immediate and late hematological effects of exposure of man to a single dose of 150 to 350 r radiation as a result of atomic bomb explosion, therapy, or accident are described in detail. The probability of radio-induced leukemia is discussed. Other topics discussed include the effects of various toxic chemicals, parasites, vegetable and animal materials, light, burns, hemorrhage, heat strokes, and seasonal changes in climate on the hematopoietic system of man and experimental animals. (354 references.) (C.H.)

**27077** HEPATIC HEMANGIOENDOTHELIOSARCOMA: REPORT OF A CASE DUE TO THORIUM. Harold L. Rakov, T. R. Smalldon, and Herbert Derman (Kingston Hospital, N. Y.). Arch. Internal Med., 112: 173-8(Aug. 1963).

The case of a 65-yr-old man who died of liver disease associated with a hemangioendotheliosarcoma, 23 yr after apparently being injected with Thorotrast, is reported. Postmortem examination showed that the liver was enlarged, and the superior surface presented hemorrhagic granular nodules measuring up to 7.0 cm in diameter. Between the nodules the liver surface exhibited a reticulated network of interlacing white lines from infiltration by foreign material. Sections of the liver showed a cirrhotic pattern. Distributed through the parenchyma were hemorrhagic nodules with a cavernous appearance showing very little structure and the presence of blood. A hepatoma was present, with metastases in adrenals, lymph nodes, and lungs. In the liver there was extensive deposition of slightly refractile, pale brown pigment granules ($ThO_2$) measuring about 1 to 2 $\mu$ each. The granules filled Kupffer cells and could also be found extracellularly in occasional hyalinized scars. The distribution of pigment was primarily portal, with the early formation of fibrous tissue connecting the portal areas. Aggregates of pigment were, however, also to be found along the hepatic veins. The tumor was anaplastic and pleomorphic, with much disruption by the hemorrhage and sometimes arranged as spindle cells in sheets. The tumor was diagnosed as hemangioendotheliosarcoma of the liver. In this case, the history of injection of a diagnostic material followed by x-ray studies of the liver, during the period of popularity of Thorotrast, seems to incriminate $ThO_2$. The reticulogranular densities described

in liver and spleen roentgenographically in this case provide further evidence. The material demonstrated in histologic sections of this case is $ThO_2$, based upon the following observations made on the specimens: the histologic appearance of the extracellular and intracellular deposits of this material is like the deposits of $ThO_2$ seen in other patients known to have received Thorotrast; its distribution in aggregates in liver, spleen, and lymph nodes is characteristic of $ThO_2$ present in the tissue for years; scintillation counting of the specimen of liver with a large iodide crystal demonstrated $\gamma$ activity of a spectrum compatible with Th and its decay products; and characteristic $\alpha$ tracks were present on autoradiographs prepared from the tissues. (BBB)

**27078** ON THE QUESTION OF SPECIFIC AND NONSPECIFIC REACTIONS OF THE SKIN TO X RAYS. H.-H. Wagner (Dermatologische (Universitäts-Klinik, Basel). Arch. Klin. Exptl. Dermatol., 216: 319-24(1963). (In German)

The applicability of the Wheal resorption time to determination of radiation effects on the skin, analogous to the spreading effect, was examined. Adult rabbits (narcotized with Nembutal, ventral skin chemically depilated) were irradiated and the frequency conductivity measured. Irradiation of controls with 50-kv x radiation produced the usual decrease in frequency conductivity (0.68 ma to 0.60 ma final). Irradiation with uv light produced no change; but irradiation with 10-kv x rays caused a slight decrease (0.68 to 0.66 ma) though they have similar penetrating power. An erythema produced by uv irradiation 20 hr previous to the test, showing the degree of Stage II, was studied and showed a decrease from 0.68 to 0.66 ma on irradiation. An erythema produced three days previously by a salve containing 2.5% $\beta$-butoxyethyl nicotinate showed a decrease from 0.68 to 0.64, and an erythema produced three days previously by a 10% acetylcholine salve showed a decrease in conductivity from 0.68 to 0.65 ma. Thus these chemical and uv applications have no effect on the reaction of skin as measured by frequency conductivity, and the processes caused by x irradiation must be distinguished from various erythemas or inflammation processes. The results may be correlated with those of Heite and Lamberts. (BBB)

**27079** THE DIFFERENT METABOLIC INJURIES TO VARIOUS ASCITES TUMOR STRAINS BY X RADIATION. H. Hilz, H. Maass, F. Hoelzel, A. Hirsch-Hoffmann, and M. Oldekop (Universität, Hamburg). Biochem. Z., 339: 198-203(1963). (In German)

A comparison of three different ascites tumors with respect to radiation injury revealed a close relationship of the decrease in DPN (diphosphopyridine nucleotide) content, inhibition of glycolysis, and inhibition of DNA synthesis, in spite of the fact that the extent of the radiation damage in the different tumors showed great variation. Since in one of the tumors, DPN content and transplantability were affected by similar x-ray doses, whereas the transplantability of the Yoshida-sarcoma was lost by doses which barely affected these parameters, another point of attack (specific for cell division?) had to be the cause for cell destruction in the latter case. (auth)

**27080** TAGUNG DER DEUTSCHEN GESELLSCHAFT FUR BIOPHYSIK VOM 25, BIS 27.4.1963 IN BADEN-BADEN. (Session of the German Society for Biophysics, April 25 to 27, 1963, Baden-Baden, Germany). Biophysik, 1: 209-428 (1964). Berlin, Springer-Verlag, 1964. DM 48,-.

Thirty-one papers and abstracts of 8 papers presented at the Session of the German Society for Biophysics, Baden-Baden, Germany, April 25 to 27, 1963, are given. Topics covered by these papers were: relative biological effectiveness in medical radiology, biophysics of relative biological effectiveness, radiochemistry and radiobiology, metabolism after irradiation, membrane phenomena and radiophysiology, and radiation genetics. Separate abstracts were prepared for 27 of the papers. (M.C.G.)

*For abstracts of individual papers see: 27020, 27043, 27081, 27082, 27083, 27084, 27085, 27086, 27087, 27088, 27089, 27090, 27091, 27092, 27093, 27094, 27095, 27096, 27097, 27098, 27214, 27215, 27216, 27217, 27500, 27501, and 27502.*

**27081** PHYSICAL BASIS FOR THE RELATIVE BIOLOGICAL EFFECTIVENESS OF DIFFERENT KINDS OF RADIATION. Dietrich Harder (Universität, Würzburg, Ger.). Biophysik, 1: 225-8(1964). (In German)

The concept of relative biological effectiveness and the importance of this parameter in clarification of radiation effects are discussed. Microscopic images of the transmission of radiation energy to matter are described. Methods of measuring relative biological effectiveness are described and a model, which shows the relation between relative biological effectiveness and the microscopic image of the energy yield by the radiation, is given. The application of the bombardment theory to the question of relative biological effectiveness was applied to an example of direct radiation effects. Results are shown in graphs. The influence of the linear energy transfer spectrum on relative biological effectiveness is discussed. (93 references). (M.C.G.)

**27082** ON THE QUESTION OF THE BURDEN OF IONIZING RADIATION FOR MANNED SPACE FLIGHT AS WELL AS FOR SUPERSONIC AND HYPERSONIC COMMERCIAL FLIGHTS. PART I. E. H. Graul (Philipps-Universität, Marburg, Ger.). Biophysik, 1: 260-81(1964). (In German)

The biophysical aspects of the radiation burden from the Van Allen radiation belts and from solar proton showers are discussed. Radiation intensities, intensity distributions, and energies and flux densities of protons and electrons in the Van Allen belts are reported. The occurrence and intensity of solar flares are also discussed. The relative biological effectiveness of protons from these flares is considered. Supersonic and hypersonic flights are discussed in regard to radiation burdens from solar protons. Some measurements of radiation doses from proton showers are presented. Radiation protection problems and the question of forecasting large proton showers are discussed. (M.C.G.)

**27083** BIOLOGICAL EFFECTS OF HIGH-ENERGY RADIATION ON PLANT SEED. H. Glubrecht, W. Scheuermann, and D. Widera (Technische Hochschule, Hanover). Biophysik, 1: 282-8(1964). (In German)

In order to study the biological effectiveness of high-energy radiation on living objects, seeds of barley and Lilium regale were irradiated with 20-Bev and 600-Mev protons and 150-kev x rays for comparison. The difficult problem of dose estimation is discussed. All together the high-energy radiation used in the experiments at estimated similar energy doses was essentially as efficient as x radiation. (tr-auth)

**27084** ON THE DEPENDENCE OF BIOLOGICAL RADIATION EFFECTS ON IRRADIATION TIME. W. Angerstein (Forschungsinstitut für Tuberkulose und Lungenkrankheiten, Berlin). Biophysik, 1: 289-96(1964). (In German)

Possibilities for the mathematical description of the dose

rate dependence of biological radiation effects are discussed. Experiments on over 3000 white male mice are described, by which the effects of dose rates on radiation effects were determined. The dose rates ranged from 1 to 140 r/min; as a measure of radiation effects $LD_{50/30}$ was used. A reaction-kinetics model for mathematical description of these results is given. With this the size of the dose effective for the organism can be given as a function of dose rate, irradiation time, and two other time constants. These time constants correspond to two independent decay processes, which consist of various chemical or physical reaction types. Measurements of the survival times of mice after irradiation are reported. (tr-auth)

**27085** ON THE KINETICS OF RADICAL REACTIONS IN X-RAY IRRADIATED FEATHER QUILLS. B. Rajewsky and A. Redhardt (Max-Planck-Institut für Biophysik, Frankfurt am Main). Biophysik, 1: 299-302(1964). (In German)

Electron spin resonance (ESR) measurements were made on irradiated feather quills to investigate the sulfur-containing radicals present. Results are shown in graphs. (M.C.G.)

**27086** EARLY INJURIES IN CELLS AFTER IONIZING IRRADIATION. H. Altmann (Osterreichische Studiengesellschaft fur Atomenergie GmbH, Seibersdorf, Austria). Biophysik, 1: 329-30(1964). (In German)

In addition to the initially observed damages to nucleic acids in cells, trace element splitting off in greater amounts appeared and thereby perhaps the secondary and tertiary structures of the macromolecules were changed. The enzyme systems were variably influenced by these metal ions. The decomposition of ribonucleic acid was facilitated by this splitting off of the trace elements in irradiation. (tr-auth)

**27087** THE EFFECTS OF X RADIATION ON METABOLIC PROCESSES IN ISOLATED ASCITES TUMOR CELL NUCLEI. F. Hoelzel and H. Maass (Universität, Hamburg). Biophysik, 1: 331-3(1964). (In German)

Metabolism measurements were made on solutions of Ehrlich ascites tumor cell nuclei. Radioinduced changes in the glycolysis chain, DPN synthesis, pyrophorylase activity, and myokinase activity were determined. (M.C.G.)

**27088** THE ENERGY METABOLISM IN VARIOUS ORGANS OF RATS AFTER WHOLE-BODY IRRADIATION WITH DIFFERENT RADIATION DOSES. H. Maass and M. Timm (Universität, Hamburg). Biophysik, 1: 334-8 (1964). (In German)

Characteristic changes in the nucleoside phosphates in various organs of rats after sublethal radiation doses were investigated. Changes in adenosine triphosphate (ATP) content in liver, thymus, and spleen with varying radiation dose were measured. The incorporation of $^{14}C$-labeled glycine in the protein of the liver, spleen, and whole blood in irradiated rats (800 r) was measured as a function of time. (M.C.G.)

**27089** CORTICOID CONTENT IN THE SUPRARENAL CAPSULES OF X-RAY IRRADIATED RATS. Muenip Yegin and Kurt Flemming (Universität, Freiburg i. B. and Heiligenberg-Instituts, Ger.). Biophysik, 1: 343-6(1964). (In German)

After whole-body x irradiation of rats with 1000 r, large changes in weight and the corticoid content of the adrenal gland appeared. The corticoid content indicated periods of arrested and increased adrenal cortex activity. Shortly before the death of the animal, which occurred mostly on the seventh day after irradiation, the hormone content of the suprarenal gland was the largest. Results are shown in diagrams. (M.C.G.)

**27090** CHANGES IN MEMBRANE-CONDITIONED CHARACTERISTICS BY MEANS OF X RADIATION. H. D. Bergeder (Universität, Bonn). Biophysik, 1: 359-63(1964). (In German)

It was found that membrane-conditioned characteristics of some tissues are changed by ionizing radiation. Nevertheless, it was not possible to determine if these changes were actual results of membrane disturbance. Examples of the changes are described. (M.C.G.)

**27091** ELECTROPHYSIOLOGICAL SYMPTOMS OF RADIOINDUCED MOTION IN MIMOSA. O. Hug, H. Miltenburger, and H. Esch (Universität, Munich and Institut für Strahlenschutzforschung, Neuherberg, Ger.). Biophysik, 1: 374-9(1964). (In German)

The electrophysiological symptoms of radioinduced immediate reactions in Mimosa pudica were investigated. The potential relations during and after irradiation of the primary petioles were determined. Electric and mechanical behavior was observed after irradiation of parts of the mimosa leaves with 17,000 r/min for 15 sec and 80,000 r/min for 10 sec. Some other plants were also studied. It was found that ionizing radiation is capable of causing action potentials in plants, which, according to course, amplitude, and stimulation rate, are not very different from those caused by other stimuli. (M.C.G.)

**27092** THE INFLUENCING OF ELECTRIC POTENTIALS OF ALGAE CELLS BY MEANS OF X RADIATION. H. Esch, H. Miltenburger, and O. Hug (Universität, Munich and Institut für Strahlenschutzforschung, Neuherberg, Ger.). Biophysik, 1: 380-8(1964). (In German)

Radiation effects on the electric characteristics of algae were studied with glass microelectrodes in internodial cells. Rest potentials were measured in light and darkness at various times after irradiation with x rays. Radioinduced changes in the form of the action potential were also observed. (M.C.G.)

**27093** SUBCORTICAL CEREBRA ELECTRIC CHANGES AFTER X-RAY IRRADIATION. H. Gangloff (Universität, Munich and Institut für Strahlenschutzforschung, Neuherberg, Ger.). Biophysik, 1: 389-90(1964). (In German)

A study was made of electric brain activity after irradiation of rabbits with x rays. A comparison was made of dose effects after head and body irradiations. Dose dependence of the radiation effects on acute activity of the rabbit hippocampus was observed. The effects after body irradiation appeared to increase rapidly between 10 and 25 r and reached quickly an almost constant plateau up to 1000 r. The effects after head irradiation increased with increasing dose up to a maximum at 200 to 400 r. There was a decrease in radiation effects in the dose region between 400 and 1000 r. (M.C.G.)

**27094** RADIOCHEMICAL REACTIONS FOR CLARIFICATION OF MOLECULAR-GENETIC PROCESSES. L. Traeger, G. Tuerck, M. Ishimoto, and A. Wacker (Universität, Frankfurt am Main). Biophysik, 1: 403-6(1964). (In German)

Photochemical or photodynamic reactions of DNA and its bases were used to investigate the code for amino acid in protein synthesis. It was found that the uv-induced radiochemical changes in nucleic acid bases and the photodynamic destruction and resistance of the bases offer a possibility for investigation of the complex processes in protein synthesis with reference to the transmission of information by DNA and RNA. (M.C.G.)

**27095** X-RAY- AND UV-INDUCED RECESSIVE LETHAL MUTATIONS IN SACCHAROMYCES. Wolfgang La-

skowski and Klaus Haefner (Freie Universität, Berlin). Biophysik, 1: 407-12(1964). (In German)

Radioinduced lethal changes in the genetic succession in Gottung Saccharomyces yeast were investigated. Estimates of the number of recessive-lethal mutable genes and the probability of mutations induced by ultraviolet and x radiation from theoretical assumptions based on a comparison of the radiosensitivity of haploid, diploid, or tetraploid strains were compared with experimental results. The distinct x-ray sensitivity of x-ray-induced and uv-induced heterozygotes for a recessive lethal factor indicated that uv and x radiation do not induce recessive lethal mutations of the same critical function units of the genome. (M.C.G.)

**27096** ON THE UV INDUCTION OF PROTOTROPHER MUTATIONS IN SACCHAROMYCES. Klaus Haefner (Freie Universität, Berlin). Biophysik, 1: 413-17(1964). (In German)

The effects of radiation dose and degree of ploidy on the uv-induced mutability of non-lethal genes in saccharomyces were studied. The mutation rate increased approximately quadratically or with higher powers with the ultraviolet radiation dose. The mutation rate decreased with increasing ploidy. (M.C.G.)

**27097** ON THE MUTAGENIC EFFECTS OF X RADIATION, N-NITROSO-N-METHYL-URETHAN, AND N-NITROSO-MORPHOLINE IN DROSOPHILA MELANOGASTER. H. Henke, G. Hoehne, and H. A. Kuenkel (Universität, Hamburg). Biophysik, 1: 418-21(1964). (In German)

The mutagenic effects of N-nitroso-N-methyl urethan and N-nitroso-morpholine were compared with those of x rays on Drosophila melanogaster. Lethal factors as well as II/III translocations were determined by the hybridization method. Mutation rates for lethal factors were 0.60% in the controls, 7.92% in irradiated, 2.52% in N-nitroso-N-methyl-urethan-treated, and 2.17% in N-nitroso-morpholine-treated Drosophila. Mutation rates for translocations were 0, 2.94, 0.18, and 0.11%, respectively. (M.C.G.)

**27098** ON THE SPECTRUM OF SOME BIOCHEMICAL MUTATIONS IN ESCHERICHIA COLI AFTER ACTION OF X RADIATION AND CANCEROGENIC SUBSTANCES. A. Trams and H. A. Kuenkel (Universität, Hamburg). Biophysik, 1: 422-6(1964). (In German)

The mutagenic effects of x radiation and N-nitroso-N-methyl-urethan on E. coli were investigated. Both were found to have strong effects and to be distinguishable. (M.C.G.)

**27099** EXPERIMENTS ON THE INCREASE OF THE BIOLOGICAL EFFECTIVENESS OF FAST ELECTRONS WITH DEPTH. F. Wachsmann and G. Korb (Universität, Erlangen-Nürnberg, Ger.). Biophysik, 2: 11-15(1964). (In German)

By the bombardment of pea seeds and other biological materials with 17-Mev electrons, experiments showed, at about 4 cm water depth for the same dose rate and dose, a greater biological effectiveness by about 1.25-fold than the value obtained at the surface. The increase in relative biological effectiveness is due to the increase in ionization density caused by the slowed electrons. (M.C.G.)

**27100** ON THE QUESTION OF THE MODE OF ACTION OF A RADON-CONTAINING ATMOSPHERE ON EMBRYONIC STATES OF DROSOPHILA MELANOGASTER. Juergen Ammon (Max Planck-Institut fur Biophysik, Frankfurt am Main). Biophysik, 2: 29-41(1964). (In German)

An investigation was made of the biological action mechanism of radon and its decay products on Drosophila eggs in an atmosphere enriched with radon. It was found that the reduction of the hatching rate of the eggs is due in the first place to alpha radiation which is caused by the deposition of radon decay products on the eggs and their support. The dose-effect curves for the lowering of the hatching rate were plotted. (M.C.G.)

**27101** EFFECTS OF RADIATION ON BLOOD GLYCOGENOLYSIS AND GLYCOGEN SYNTHESIS. D. Bonsignore, C. Canonica, O. Sartori, and L. Lenzerini (C.A.M.E.N., Pisa, Italy). Boll. Soc. Ital. Biol. Sper., 39: 1451-4 (Dec. 15, 1963). (In Italian)

The effect of radiation on glycogen content of the blood in rats was examined under conditions of hypoalimentation and fasting. Wistar rats weighing about 200 g were totally irradiated with 700 r and then placed on reduced diets or else given no food. Glycogen analysis was carried out by the method of van der Klai and results checked by comparison with analyses by the method of Roe. The mean value found for 37 normal animals was 4.42 ± 0.96 g glycogen/100 g of fresh tissue. The mean values for five control animals in each determination kept on reduced diets were: after six hr, 3.31; after 24 hr, 3.03; after 48 hr, 0.97; after 72 hr, 96 hr, and 144 hr, all 0.40. Similar values for five irradiated animals: after six hr, 3.48; after 24 hr, 3.18; after 48 hr, 3.07; after 72 hr, 3.94; after 96 hr, 0.90; after 144 hr, 0.38. Values for animals (controls and irradiated animals, respectively, three animals per lot) under conditions of fasting were as follows: after 12 hr, 0.40, 1.05; after 24 hr, 0.60, 1.21; after 48 hr, 0.74, 2.33; after 72 hr, 1.20, 0.78; after 96 hr, 1.36, 0.16; after 120 hr, 0.86, 0.35; after 144 hr, 0.43, 0.38. The increase in blood glycogen around 72 hr in hypoalimentation and around 48 hr in fasting is caused by some metabolic phenomenon whose nature is currently being investigated. (BBB)

**27102** HEXOKINASE ACTIVITY IN THE LIVER OF IRRADIATED RATS. D. Bonsignore, C. Canonica, O. Sartori, and L. Lenzerini (C.A.M.E.N., Pisa, Italy). Boll. Soc. Ital. Biol. Sper., 39: 1455-7(Dec. 15, 1963). (In Italian)

It was previously observed that glycogen increases in rats irradiated with 700 r, especially 48 to 72 hr after irradiation when the animals are maintained in hypoalimentation, and earlier when they are starved. The first of the enzymes connected with glycogen biosynthesis and breakdown, hexokinase, is examined. Enzyme activity of the liver was studied on four lots of three animals each irradiated with 700 r, maintained without food, and sacrificed after 12, 24, 48, and 72 hr. Hexokinase activity was measured by the method of Bennett, et al. The unit of hexokinase was taken as the amount causing a change of 0.01/min in the optical density at 340 mμ. This arises through reduction of NADP in the method of analysis. The following results were obtained for units of hexokinase/mg protein. Control animals after 12 hr, 10.2, 14.3, 9.7, average 11.4; after 24 hr, 13.2, 12.4, 10.0, average 11.9; after 48 hr, 13.3, 8.9, 7.5, average 9.9; after 72 hr, 10.0, 13.7, 16.5, average 13.4. Irradiated animals after 12 hr, 12.1, 10.0, 8.4, average 10.2; after 24 hr, 9.5, 9.8, 10.0, average 9.8; after 48 hr, 11.6, 13.4, 10.6, average 11.8; after 72 hr, 10.9, 8.3, 8.5, average 9.2. Discussion of these results was reserved until the remaining enzymatic activities related to synthesis and breakdown of glycogen had been studied. (BBB)

**27103** PHOSPHOGLUCOMUTASE ACTIVITY IN THE LIVER OF IRRADIATED RATS. D. Bonsignore, C. Canonica, O. Sartori, and L. Lenzerini (C.A.M.E.N., Pisa, Italy). Boll. Soc. Ital. Biol. Sper., 39: 1668-70(Dec. 31, 1963). (In Italian)

Phosphoglucomutase activity was determined on 39 rats irradiated with 700 r, maintained without food, and sacrificed after 12, 24, 48, and 72 hr, as part of a study of the effects of radiation on blood glycogen. Activity of the enzyme was measured by a spectrophotometric technique using the reduction of NADP and following the method of Bonsignore et al. The following results were obtained taking as the unit the quantity of enzyme which produced a change of 0.01/min in the optical density at 340 mμ under similar experimental conditions. There were 59 control animals; in these a normally fed sample had phosphoglucomutase activity and standard error of 72.3 ± 2.6; after 12-hr fast, 81.8 ± 4.2 (13% increase); after 24-hr fast, 69.4 ± 5.0 (4% decrease); after 48-hr fast, 58.3 ± 3.2 (19% decrease); after 72-hr fast, 67.9 ± 4.0 (6% decrease). The irradiated animals gave the following results: after 12-hr fast, 82.8 ± 3.4 (14.5% increase); after 24-hr fast, 64.1 ± 6.1 (11% decrease); after 48-hr fast, 56.5 ± 5.5 (22% decrease); after 72-hr fast, 69.5 ± 6.3 (4% decrease). Discussion of the results was postponed until completion of experimentation on enzymatic activity connected with the synthesis and scission of glycogen. (BBB)

**27104** MORPHOLOGICAL AND CYTOLOGICAL CHANGES OF RHIZOBIUM AS INFLUENCED BY GAMMA RAYS AND BY RADIOMIMETIC SUBSTANCES. K. Dygdala (Marie Curie-Sklodowska Univ., Lublin, Poland). Bull. Acad. Polon. Sci., Ser. Sci. Biol., 10: 381-2(1962).

Two strains of Rhizobium leguminosarum (from peas) were irradiated with γ rays or treated with either triethylenemelamine (TEM) or Novoembichin. Irradiation was applied during a 17-hr period at doses of 8 or 12 r/min. In the radiomimetic tests, cytologic observations were made on cultures treated with 100 to 500 μg/ml of TEM or Novoembichin. In normal cells of R. leguminosarum the chromatin substance undergoes the same transformation as in other bacterial species; only the lag phase before division lasts longer than in some other bacterial species, such as Escherichia coli. Transformation of Rhizobium rods into bacteroids was noted; young bacteroids still had the ability to divide. Polar growth of normal Rhizobium cells was also noted. After division the newly formed cells began to grow at one of the two poles. Similar growth was noted in some other species of bacteria. The following changes were noted in the cells that survived irradiation or treatment with the radiomimetic substances: cell division was much delayed or totally arrested; directly after these treatments, chromatin was aggregated; and after a few hours of culture it became diffused or even totally disappeared; the reducing sites (probably mitochondria) swelled and stained more strongly, and were, therefore, more distinct than in untreated cells; and the quantity of lipids was larger than in normal cells, but it could not be determined whether this resulted from irregular metabolism of whole cells or whether the mitochondria were transformed to lipid droplets. The irradiated cells multiplied by division in the same way as normal cells. (BBB)

**27105** A BIOLOGICAL METHOD FOR DETECTING AND EVALUATING RADIATION EFFECTS IN THE RANGE OF 25-125 ROENTGENS. Takeo Suzuki (Inst. of Public Health, Tokyo), Kiyofumi Ishikawa, Yoji Minagawa, and Masami Kaihara. Bull. Inst. Public Health (Tokyo), 12: 145-59(Sept. 1963).

Experiments were conducted on mature male rabbits, which had been exposed to ionizing radiation, by using the carbon black $^{32}P$ method. To clarify how the phagocytotic activity would change as a result of irradiation in the range of 125 and 25 r, the experiments were conducted in 3 series: single whole-body irradiation of 125, 100, 75, 50, and 25 r; 100-r whole-body irradiation in four installments at a rate of 25 r a week; and 50 r whole-body irradiation in two installments at a rate of 25 a week. Changes in body weight, erythrocyte count, leukocyte count, hemoglobin level, and the percentage of phagocytosing neutrophils were investigated. In the series of experiments salient effects were observed on body weight and leucocyte count in the 125-r single-exposure group, and only a slight change was detected in leukocyte count in the 100-r single-exposure group. A 25-r single exposure and 50r irradiation fractionated into two 25r did not induce any detectable effect on phagocytosis, while the other exposures induced remarkable effects. It was also found that the effect of fractionated irradiations was induced more gradually and to a slighter degree than those of single exposures in the same dose. (Public Health Eng. Abstr., Vol. 44, No. 5, May 1964).

**27106** EFFECT OF RADIATION ON THE SEMINIFEROUS TUBULES. Tadashi Adachi, Masatoyo Akiyoshi, Chikara Shima, and Aiko Shima. Bull. Tokyo Med. Dental Univ., 9: 113-27(June 1962).

Results are reported from studies on the effects of x radiation on growth and growth rate of seminiferous tubules in mouse testicles. It was concluded that x radiation affects the rate of growth of germinal cells and results in shorter seminiferous tubules than in nonirradiated animals. (C.H.)

**27107** EFFECT OF RADIATION ON CHICK EMBRYO. Tadashi Adachi and Shūichi Mikuriya. Bull. Tokyo Med. Dental Univ., 9: 499-517(Dec. 1962).

Chick embryos were x irradiated during their three stages of embryonal development, i.e., 4th day, 11th day, and 18th day. As dose of radiation increased, increasing death rate of chick embryos was observed. There were two kinds of death of chick embryo, acute death and delayed death. Acute death meant the death within 24 hr after irradiation, and one of its causes was suggested as hemorrhages appearing subcutaneously as well as in many internal organs. Acute death was seen in the groups irradiated in the later embryonic stage (18 and 11-day chick embryos). The survival (hatch) rate $LD_{50}$ was 360 r for 4-day chick embryos, 420 r for 11-day chick embryos, and 510 r for 18-day chick embryos. Among the surviving chick embryos, prolongation of hatching time was observed. As for the hatched chickens, the irradiated groups showed some deteriorating effects on growth of body. Body weight curves were lowered compared with the nonirradiated control. The 4-day chick embryo was most radiosensitive, followed by the 18-day chick embryo. The 11-day chick embryo showed the least damage. Death of chickens, obvious also in groups irradiated as 4- and 18-day chick embryos, seemed to be related to the symptoms of diarrhea and limb anomalies. Malformations were seen in the surviving and also in the dead-in-shell chickens. Malformations could be detected in the hard tissue, limbs, claws, feathers, and beaks, and incomplete closure of umbilicus was included as such. Malformation occurred most frequently in 4-day chick embryos, next in 18-day chick embryos, and least in 11-day chick embryos. In the single irradiation, limb anomalies were most prominent, and in the fractionated, irradiation anomalies of the feathers were marked. Malformations of the eye and the cranium were not observed in this experiment. Histological studies on the bone tissue of the hatched chickens that seemed to be apparently normal revealed considerable injuries to the bone growth. (auth)

**27108** ON THE SENSITIVITY OF HAMSTER MELANOMA TO X IRRADIATION, COLD, CYTOSTATICS, AND IMMUNOLOGIC INFLUENCES. T. Salamon and H. Storck (Universität, Zurich). Dermatologica, 127: 83-5(1963). (In German)

The in vitro sensitivity of the transplantable hamster melanotic melanoma (M. Mel. 1) to physical and chemical agents was studied. Recently removed melanoma tissue was irradiated with 600-, 3000-, 4500-, and 6000-r doses of x rays then transplanted to test its viability. The tumor required increasingly long periods for perceptible growth with increasing x-ray doses up to 4500 r. After 6000-r irradiation the tumor cells were apparently irreversibly damaged since the recipient animals did not develop tumors. However, some hamsters injected with heavily irradiated tumors died in 1 to 3 weeks from causes that could not be determined. Cooling tumor tissue to −28°C for 11, 23, and 48 days progressively increased the time for appearance of tumors in animals injected with the frozen material. The tumor was more sensitive to thio-TEPA (triethylenethiophosphoramide) than to Cytoxan (cyclophosphoramide). The melanoma did not selectively take up $^{131}I$ in vivo. No active or passive immunization to the tumor could be demonstrated: 2 to 3 injections of tumor material or injection of serum from hamsters bearing the tumor did not appear to retard tumor growth in the recipients. (BBB)

**27109** MECHANISM OF ACCELERATED DEVELOPMENT OF RADIATION CATARACTS CAUSED BY A PRICK IN THE IRRADIATED CRYSTALLINE LENS. V. V. Popov, V. A. Golichenkov, A. I. Farberov, and Z. A. Sokolova (Moscow State Univ.). Dokl. Akad. Nauk SSSR, 155: 940-3 (Apr. 1, 1964). (In Russian)

The development of radiation cataracts after pricking the crystalline lens was studied using 149 frogs (52 controls). It was found that 500 r is the minimum dose capable of inducing small cataracts after pricking. Cataracts begin to appear on the 3rd or 7th day after exposure. At first the variations are identical to those in a non-irradiated lens, however, after a short time the lens exhibits signs of radioinduced cataracts. During exposure to higher doses, turbidity of the lens stops at 15,000 r. An observed regularity shows that following maximum exposure and pricking the turbid lens does not exhibit, in the early stages, the typical histogenetic processes inherent to radiation cataract. (R.V.J.)

**27110** DISTRIBUTION OF $^{32}P$ IN ORGANS OF RATS AFTER X-IRRADIATION AND AFTER THE ADMINISTRATION OF TS160 AND METHIONINE SULPHOXIMINE. Z. Dienstbier, J. Kolousek, and F. Vitek (Charles Univ., Prague). Folia Biol. (Prague), 10: 135-42(1964).

The effect of x irradiation on the distribution of $^{32}P$ in rat organs over a period of one to 14 days after irradiation was compared with the effect of a single dose of methionine sulfoximine and of the preparation TS-160 (trischlorethylamine chloride) Spofa. The bone marrow, thymus, spleen, liver, pancreas, brain, and bone (tibia) of male rats were studied. It was found that x irradiation with a dose of 600 r inhibited the incorporation of radiophosphorus in all the organs except the pancreas. TS-160 (Spofa) inhibited the utilization of radiophosphorus on the first and third day in the bone marrow and to a lesser degree in the thymus. After 24 hr, no lowering of activity was found in any of the organs except the brain; on the contrary, a significant increase in $^{32}P$ activity was found in the spleen, the liver, and the pancreas, which persisted over the first and third day. After methionine sulfoximine, the utilization of $^{32}P$ was inhibited in the bone marrow on the first three days. In the thymus and bone, activity was already lower at the 24-hr interval. No marked increase in $^{32}P$ activity was observed after the administration of methionine sulfoximine. A slight increase in the utilization of radiophosphorus in liver was found 24 hr after the administration of methionine sulfoximine. The results show that x irradiation, TS-160, and methionine sulfoximine interfere in the mechanism regulating P metabolism in the organism of experimental rats, but by different mechanisms. (auth)

**27111** EFFECTS OF A SINGLE LOCALIZED PROTON IRRADIATION ON THE ELECTROPHYSIOLOGIC POTENTIALS ELICITED IN THE LATERAL GENICULATE GANGLION OF THE CAT. J. Siegfried, F. R. Ervin, A. Koehler, and R. N. Kjellberg (Universität, Zurich). Helv. Physiol. Pharmacol. Acta, 20: C83-4(1962). (In French)

In 26 cats the ganglion on one side was irradiated with protons, the contralateral ganglion serving as a control, and potentials were registered after stimulation by implanted electrodes. The ganglion was irradiated with 159-Mev protons, collimated to a beam of 3-mm dia, generated by the Harvard University synchrocyclotron. A stereotactic technique was used to ensure that the ganglion was irradiated at the Bragg peak of the proton beam; one port was used and doses of 20,000 and 30,000 rad were given. The potential induced in the ganglion on the 30,000-rad irradiated side, induced by stimulation at the chiasm, was clearly diminished by the second day postirradiation. The potential was further depressed the fourth day and no response could be elicited on the sixth day after the 30,000-rad dose. At a distance of 3 mm from the lesion, a weak response could be obtained on the sixth day. With 20,000-rad doses similar effects were seen but after a longer latent period. Thus, after the lower dose stimulation of the chiasm caused a diminished electric response in the ganglion on the sixth day, a weaker response on the tenth day, and none at all on the twelfth day. These results, showing that relatively high doses of radiation are required to produce acute effects on neurophysiologic function, are in accord with similar, previously reported experiments. The modifications of bioelectric response in the proximity of the radiation-induced lesion are attributed to development of edema at these sites. The clinical possibilities of the use of intracerebral proton irradiation, utilizing the Bragg peak for maximal destructive effect, are briefly discussed. (BBB)

**27112** RADIOSENSITIVITY OF DROSOPHILA SPERMATOGONIA. Per Oftedal (Norsk Hydro's Inst. for Cancer Research, Montebello, Norway). Hereditas, 48: 543 (1962).

A study was made of the dose-effect relation for Drosophila spermatogonia x irradiated in the range 0 to 168 r. Embryos of about 18-hr age were irradiated with 55, 110, and 165 r, and male flies from these embryos were mated singly to M5 females. From the progeny of each culture, a single heterozygous M5/+ female was tested for the presence of a sex-linked lethal. In this way, one spermatogonium is tested from each irradiated male, and the problem of clusters of lethals avoided. About 60 series of irradiations were done, with the number of tested chromosomes being about 25,000 for controls, and about 20,000 for each dose. The total number of lethals was about 70 in the control group, and between 80 and 90 in each of the irradiated groups. The results indicate that the initial slope of the dose-effect curve may be quite close to that obtained previously by irradiation of mature sperm. With increasing doses, the curve flattens off. This may be caused by an in-

creasing elimination of germ cells with increasing dose. The flattening off of the curve was demonstrated conclusively with a higher dose (300 r). (BBB)

**27113** ON THE RELATION BETWEEN ANEMIA-CAUSING FACTOR IN RED CORPUSCLES EXPOSED TO X RAYS, RED CORPUSCLE GENERATING FACTOR, AND CONSTITUENTS OF RED CORPUSCLES. Kiyoshi Koizumi (Hokkaido Univ., Sapporo). Hokkaido Igaku Zasshi, 36: 189-200(Apr. 1961). (In Japanese)

Anemia induced by injections of red cells exposed to x rays was investigated with respect to the stroma constituents of the cells. Extracts of red cell stroma of rabbits were fractionated into 50% saturated, ammonium sulfate fraction (A); 100% saturated, fraction (B); and alcohol-treated supernatant fraction (C). These three fractions were exposed to 20,000 r each and reinjected. They were compared with nonirradiated fractions with regard to their influence on the blood picture of healthy rabbits and anemia in rabbits induced by bleeding. No anemia in healthy rabbits was produced by exposed or nonexposed whole blood cells, nonexposed stroma, nonexposed fraction B, and exposed and nonexposed fraction C, but they produced by exposed stroma and exposed fraction B. The influence on the amount of time rabbits took in recovering from anemia following the bleedings were as follows: in the case of fraction B the time was the same as in controls, with exposed stroma and exposed-fraction B the time was lengthened, and with stroma and exposed and nonexposed fraction C the time was shortened. Thus the induced anemia action by irradiated red cells was caused by the fraction precipitated by saturated ammonium sulfate. The supernatant facilitated recovery from anemia when it had not been irradiated. (BBB)

**27114** PSEUDO-EPITHELIOMATOUS HYPERPLASIA—A CASE REPORT. S. H. Blau and J. A. Guerra (Seton Hall Coll. of Medicine, Jersey City, N. J.). J. Am. Podiat. Assoc., 52: 838-9(Oct. 1962).

This case calls attention to the harmful effects that may result from a prolonged course of radiation therapy in treatment of plantar warts. The patient developed a large radiation ulcer on the right foot plantar area. He had undergone a course of radiation therapy, for one year, administered at monthly intervals, and was informed by the radiologist that the treatments would result in the falling off of the wart on his foot. The patient noted after 10 months of the radiation therapy that the lesion was becoming larger and larger, and also was developing a discharging odorous slough. The pain became severe. A tentative diagnosis was made of either malignancy or radiodermatitis with ulceration. Biopsy specimens submitted for pathologic study showed unusually severe proliferation of stratified squamous epithelium, extending deep into the dermis. There was also ulceration, hemorrhage, edema, and inflammation. Although the deep proliferation of the squamous epithelium raised a suspicion about neoplasm, it was noted that the squamous cells were orderly and without any evidence of phenomorphism or anaplasia. In view of these features it was diagnosed as a benign lesion. Under local anesthesia the entire area was excised down to the metatarsal heads with debridement of all necrotic tissue. Three weeks later progressive healing of the area was apparent, and the patient was able to return to work. (BBB)

**27115** CROSS-RESISTANCE RELATIONSHIPS IN ESCHERICHIA COLI BETWEEN ULTRAVIOLET RADIATION AND NITROUS ACID. Antonio Zampieri and Joseph Greenberg (Palo Alto Medical Research Foundation, Calif.). J. Bacteriol., 87: 1094-9(May 1964).

A number of radiosensitive and radioresistant strains of Escherichia coli were tested for sensitivity to injury by nitrous acid. All the radioresistant strains, including 13 radioresistant mutants of strain S, B/r, Bpr5, and K-12, were found to be significantly more resistant to nitrous acid than were the radiosensitive strains S and B. The radioresistant mutants of strain S, Bpr5, and K-12 displayed similar responses to nitrous acid and were less resistant than was strain B/r. Strains B and S were indistinguishable on the basis of nitrous acid sensitivity. The survival curves of all strains examined were similar in shape to corresponding survival curves after ultraviolet radiation. The sensitivity to nitrous acid of the radiosensitive strains S and B, but not that of the radioresistant strains, was found to be greater on Tryptone medium than on Penassay medium, and greater on Penassay medium than on glucose-salts medium. Between 2 and 3% of the strain S survivors of nitrous acid treatment were radioresistant; 46 such radioresistant mutants were isolated and found to be identical in cross-resistance pattern with radioresistant types ($R_3$, $R_4$, or $R_6$) previously described. The proportions in which these radioresistant types were found to occur were similar to those observed after selection by other radiomimetic agents. (auth)

**27116** CARBOHYDRATE AND LIPID CONTENT OF RADIATION-RESISTANT AND SENSITIVE STRAINS OF ESCHERICHIA COLI. E. E. Woodside and W. Kocholaty (Army Medical Research Lab., Fort Knox, Ky.). J. Bacteriol., 87: 1140-6(May 1964).

Total lipid contents of acetate minimal medium cultures of Escherichia coli, strains B, B/r, and $B_s$, were not significantly different when identical pretreatment and extraction procedures were compared. Wide variations in intracellular hexose and pentose derivatives of E. coli B, B/r, and $B_s$ were induced by changes in carbon and nitrogen sources and by changes in the growth phases. The three strains produced more intracellular carbohydrate when grown in nutrient broth-glucose medium than when grown in unsupplemented nutrient broth. Acetate minimal medium cultures of the radiation-sensitive mutant, E. coli $B_s$, contained the least, and the radiation-resistant mutant, E. coli B/r the largest, amounts of intracellular hexoses. Environmental conditions which increased the radiation resistance of E. coli B/r were similar to the environmental conditions which favored increased intracellular hexose accumulation. After X ray of E. coli B/r, considerable amounts of hexoses and pentoses were released into the growth medium. Alterations in hexose distribution patterns of x-rayed E. coli B/r preceded alterations in pentose distribution patterns. Prolonged postirradiation incubation resulted in a net synthesis of extracellular hexose, with concomitant loss of intracellular hexose accumulation. (auth)

**27117** THE ACUTE RADIATION SYNDROME. C. M. Gurner (Toorak, Victoria, Australia). J. Coll. Radiologist Australasia, 7: 216-19(Oct. 1963).

The acute effects of radiation are grouped into central nervous system effects, gastrointestinal effects, and bone marrow or hemopoietic effects; effects in these categories are outlined. Biochemical and pathologic findings in circulating blood cells, bone marrow, and intestinal mucosa are outlined. The assessment of the degree of radiation injury, both physically and clinically, is discussed. It is concluded that the final assessment of the degree of radiation damage sustained by a casualty will be made on the clinical findings, supported by serial blood examinations, and perhaps by biochemical and physical estimations, but the early assessment can only be made by knowledge of the physical

circumstances of the accident and by the rapidity of appearance of the symptoms and their severity. (BBB)

**27118** TEMPERATURE OF MAXIMUM CONTRACTION OF MOUSE COLLAGEN FIBERS AS INFLUENCED BY AGING, X RADIATION, AND BREEDING STATUS. E. B. Darden, Jr., and A. C. Upton (Oak Ridge National Lab., Tenn.). J. Gerontol., 19: 62-5(Jan. 1964).

A method was developed to investigate the temperature of maximum contraction (TMC) of individual tail-tendon fibers as an age-related variable. Fibers began to contract at 57 ± 1°C and continued to shorten with rising temperature until TMC was reached. Relaxation and stretching then followed, as the fibers changed from a strong, almost nonextensible state to a weak, elastic, gelatinous condition. Individual fibers from the same animal varied less than individual fibers from different animals, with standard deviations per fiber of 0.72°C and 1.88°C, respectively. Tail tendon fibers from virgin mice irradiated at two to four months of age with a single 450-r whole-body exposure showed throughout their subsequent life span an age-dependent increase in the mean TMC indistinguishable from that of fibers from unirradiated controls. This indicates that an amount of whole-body radiation, which can cause life-shortening and signs suggestive of premature aging in other tissues, fails to affect the TMC of tail tendon fibers. Fibers from mice that were breeders showed little or no correlation between mean TMC and age (10 to 37 months). This implies the influence of other variables on age-dependent changes in collagen (i.e., reproductive, hormonal, nutritional, or stress factors), the role of which remains to be established. (BBB)

**27119** STUDIES ON THE COMPARATIVE PHYSIOLOGY OF AGING. III. EFFECTS OF X-RADIATION DOSAGE ON AGE-SPECIFIC MORTALITY RATES OF DROSOPHILA MELANOGASTER AND CAMPANULARIA FLEXUOSA. Bernard L. Strehler (Baltimore City Hospitals). J. Gerontol., 19: 83-7(Jan. 1964).

The quantitative relation between radiation dosage and life shortening was determined for two widely different species of invertebrates, an insect, Drosophila melanogaster, and a colonial marine hydroid, Campanularia flexuosa. Individually housed Drosophila were exposed to x-radiation dosages ranging from 1000 to 50,000 r and the subsequent mortality was followed. An exposure of 50,000 r produced a life shortening of ~one day per 2000 r. This was calculated from the age-specific mortality rates at two different intervals after exposure to different x-ray dosages. Exposure to 1000 to 5000 r had no significant effect on mortality. The effect of x-radiation on the subsequent survivorship of Campanularia indicated an actual life-lengthening effect of ionizing radiation even at very high dosages, (~25,000 r). These facts are in conflict with mutation hypotheses of aging, at least in these species. Thus, if somatic and germ line cells are equally sensitive to radiation, the number of lethal mutations induced by 50,000 r would be nearly 1000 times greater than the number of lethal mutations which occur during the normal life span of the individual flies. Yet this enormous burden of induced mutations caused only a 20-day decrease in median longevity. At lower dosages, which yield as much as 100 times the normal rate of mutation (in the germ line), no detectable effect on the mortality curves was observable. Thus, in Drosophila, either life-shortening mutations, which are postulated to occur spontaneously in somatic cells, cannot be induced by radiation with more than 1% of the efficiency of their induction in the germ line by exposure to the same radiation, or the hypothesis that aging of these flies is due to the accumulation of spontaneous mutation is incorrect. The latter is the more likely hypothesis. (BBB)

**27120** DOUBLING TIME OF MOUSE SPLEEN CELLS DURING THE LATENT AND LOG PHASES OF PRIMARY ANTIBODY RESPONSE. Elmo E. Capalbo and T. Makinodan (Oak Ridge National Lab., Tenn.). J. Immunol., 92: 234-42(Feb. 1964).

Proliferation of various cell types following antigenic stimulation and their incorporation of $^{3}H$-thymidine was studied by culturing mouse spleen cells in 0.1-$\mu$ diffusion chambers in x-irradiated (500 r) recipients. The results show that the decrease in $T_2$ of the total cells and the increase in the number of mitotic cells after antigenic stimulation are reflections mainly of proliferative activities of blast and plasma cells. Estimates of the ratio S:GT indicate that after antigenic stimulation a significant increase was detected only among the immature plasma cells and lymphocytes. This would indicate that either the S period is prolonged or the GT decreased. Of interest also was the fact that the ratio for the reticulum-blast cells was 0.9 (68/75). This would indicate that the Gl period of these cells is very short. These results indicate that there are at least three variables in dealing with an intermediate cell compartment of a differentiation process in an immune response, i.e., the variable cell cycle dependent upon the stimulant and the input and output rates. Taking into consideration the cell compartment size, the $T_2$, $T_k$, and S:GT of each cell compartment, it can be concluded that the terminal plasma cells are the end state of differentiation of reticulum-blast cells, suggesting that if other unique somatic cells can give rise to terminal plasma cells, they must do so by feeding into the primary cell compartment. (BBB)

**27121** MUTATIONS IN METABOLIZING BACTERIAL POPULATION BY LONG-TERM CONTINUOUS IRRADIATION WITH RADIOISOTOPES, $^{32}P$, $^{35}S$, AND $^{90}Sr$. Michio Tsukamura, Sumio Tsukamura, and Shoji Mizuno (Obuso National Sanatorium, Nagoya, Japan). Japan. J. Microbiol., 6: 83-94(Dec. 1962).

The lethal and mutagenic effects of continuous irradiation with $^{32}P$, $^{35}S$, and $^{90}Sr$, on a growing and metabolizing population of a Mycobacterium avium, were studied. Continuous irradiation with $^{32}P$, added to cultures as $^{32}P$-orthophosphate at a concentration of 0.5 $\mu$C/ml caused lethal and mutagenic effects during a 4-week observation period, but the effects became insignificant after five and six weeks incubation. The effects were more prominent in Sauton medium, in which the organism grew abundantly, than in a phosphorus-deficient medium, in which it grew only slowly. However, greater amounts of $^{32}P$ were incorporated into the cells growing in the phosphorus-deficient medium than in the Sauton medium. The growing and metabolizing bacterial populations were not greatly affected by $^{32}P$ atoms incorporated in the DNA or in the total cell in the frozen state or in resting cells. The lethal effect was less in the metabolizing population than in the frozen population of cells. Addition of 5 $\mu$C of $^{35}S$-sulfate per ml to sulfur-deficient medium, in which the organism grew abundantly, caused neither mutagenic nor lethal effects on the metabolizing population, at least during the 6-week observation period, whereas the addition of 0.5 $\mu$C of $^{32}P$ phosphate per ml to the medium resulted in significant changes. Continuous irradiation of the organism, growing slowly in a phosphorus-deficient medium containing 2 $\mu$C of $^{90}Sr$ nitrate per ml for a 285-day period, caused a significant increase (27-fold) in mutation frequency to isoniazid resistance but caused only a slight increase (3-fold) in

viability. It is evident that, in the growing and metabolizing populations, as in resting cells, lethal and mutagenic effects are produced chiefly by transmutation of the isotope and of mutation frequency without significant loss in viability. (BBB)

**27122** INFLUENCE OF THE MICROBIAL FLORA UPON RESPONSE OF SERUM γ-GLOBULIN AND LYMPHATIC TISSUE TO IRRADIATION. Heinz Bauer, Richard E. Horowitz, Fiorenzo Paronetto, Albert Einheber, Gerald D. Abrams, and Hans Popper (Walter Reed Army Inst. of Research, Washington, D. C.). Lab. Invest., 13: 381-8(Apr. 1964).

Experiments were designed to study the morphology and function of phagocytic and immunocytic elements in the lymphatic tissue of irradiated germ-free and conventional mice by histologic, autoradiographic, immunocytochemical, and serologic techniques to determine whether a living microflora effects the cytologic and functional response of lymphatic tissue to irradiation. Germ-free and conventional mice received 550 r whole-body irradiation and the known radioresistance of germ-free animals was confirmed. Study of lymph nodes and spleens revealed a rapid destruction of lymphocytes, a gradual accumulation of hemosiderin and lipofuscin in macrophages, and an immune response which was manifested by the appearance of newly formed immunoblasts and γ-globulin-containing plasma cells. These phenomena occurred both in germ-free and conventional lymphatic tissue. Since the postirradiation immune response of lymphatic tissue develops both in germ-free and conventional animals, it cannot be explained by living microorganisms alone. Other factors, such as antigenic or adjuvant effects of tissue breakdown products or a nonspecific stimulation of γ-globulin forming cells by irradiation, have to be considered. Following a morphologically equal immune response during the recovery period, a significant rise in serum γ-globulin occurred in the germ-free and a decline in the conventional mice. Thus, the bacterial flora of the conventional mice influenced the loss of γ-globulin which has been previously attributed to the effect of radiation alone. (BBB)

**27123** EFFECTS OF DIAGNOSTIC IRRADIATION. Alice Stewart (Oxford Univ.). Lancet, 1: 718(Mar. 30, 1963).

Criticisms advanced by Lindsay (17: 33694, 33695) and by Rabinowitch against the Oxford survey, showing a correlation between x irradiation in utero and later development of leukemia, are answered. Moreover, the infection theory proposed by Rabinowitch to explain the Oxford findings is criticized. This theory holds that the preleukemic stage might predispose to bacterial infections. The recent increase in leukemia mortality might be largely due to the fact that pneumonia and related infections have become less lethal than they were 40 yr ago, and therefore less likely to cause a misdiagnosis of the fundamental cause of death when they are provoked by the preleukemic state. However, Rabinowitch quotes numbers of deaths per annum and ignores the increasing birth rate, thus failing to notice that the annual numbers of deaths ascribed to birth injury and postnatal asphyxia per 1000 live births were not significantly greater during 1952 to 56 than they were during 1957 to 61, although far fewer infant deaths were relegated to the category of ill-defined causes during the second period. This fundamental error invalidates all of Rabinowitch's subsequent arguments and suggestions. The infection theory of leukemia does not explain: the inverse correlation between pneumonia deaths and leukemia deaths in childhood during the period 1920 to 1959; the greater increase in leukemia mortality at the extremes of life than in intermediate age groups: the high leukemia mortality in populations with low pneumonia death rates, and vice versa; the recent recognition of the association between mongolism and leukemia; the greater frequency of leukemia onset in the summer than in the winter; the relatively high incidence of leukemia among first-born children of preschool age; and the rarity of leukemia in both members of a twin set. (BBB)

**27124** RADIATION-INDUCED LEUKEMIA. W. M. Court Brown (Western General Hospital, Edinburgh). Lancet, 2: 1071(Nov. 16, 1963).

Previous reports suggesting that the occurrence in leukemia patients of a normal karyotype in bone marrow cells is evidence against the leukemia being radioinduced are criticized. There are not sufficient data on the chromosome constitution of leukemic marrow cells, with or without a prior history of therapeutic radiation exposure, to permit a decision as to whether a particular constitution favors the disease being radiation-induced or not. In one report, five out of seven patients with acute leukemia, possibly radioinduced, showed chromosome abnormalities, while 15 without a radiation history did not. From the standpoint of present knowledge, these data should be treated with circumspection; the chromosome studies were done either on cultures of bone marrow or of blood, and there is now reason to believe that such results can be misleading. Culture techniques for marrow and blood were originally devised for the study of nonleukemic cells, and it is now known that the conditions of culture can select against abnormal cell lines. Therefore a negative result on cultured material is meaningless, while a positive result with chromosome abnormalities may not necessarily reflect the whole constitution of the marrow. Too much reliance should not be placed on results other than those obtained utilizing a direct marrow technique in which there is no preliminary culture period. A further difficulty in the reported data is that some cases were treated while others were untreated at the time of study. There may exist cytogenetical differences between the leukemias which are probably radiation-induced and those that are probably not. Since radioinduced leukemia is a source of great public concern, it should be established whether such cases show any differences from those without a prior history of exposure. The finding of differences might be helpful in elucidating the mechanisms of radiation leukemogenesis. Many cases of leukemia are examined and treated without any inquiry ever being made as to whether there is a history of previous therapeutic radiation exposure. If such an inquiry was routinely made and if in all cases of leukemia direct marrow studies were done by an experienced cytogeneticist, some of answers might be found quickly. (BBB)

**27125** EFFECT OF RADIOACTIVE COBALT IRRADIATION ON THE MERISTEMATIC CELLS OF RYE AND WHEAT. V. Kiece. Latvijas PSR Zinatnu Akad. Vestis, No. 1, 41-4(1964). (In Latvian)

Results of differences caused by various methods of irradiation of identical capacity are reported. By a single irradiation of the seeds before sowing, a certain amount of cells undergo the effect of x rays. With x irradiation of longer duration all cells are affected and give rise to a great number of gigantic nuclei and cells. It was further proved that the effect produced by x rays in rye and wheat seeds causes various alterations in them, the number of these depending on the increased radiation dosage. By irradiation of longer duration many cells in mitosis are affected by irradiation. If mitosis is of short duration, pro-

phase is stopped and the nuclei assume greater dimensions. The growth of cells, in its turn, stimulates the growth of plants and leads to increase of yield. (auth)

**27126** PRIMARY NEOPLASIA OF THE LIVER FOLLOWING THORIUM SALTS. A. Gimenez-Salinas and Salvador Braso (Hospital de la Santa Cruz y San Pablo, Barcelona). Med. Clin. (Barcelona), 40: 48-50(Jan. 1963). (In Spanish)

Laboratory tests and x-ray examinations of a 70-yr-old patient with jaundice, choluria, and acholia showed the presence of a calcified hydatid cyst in the right liver lobe. Also present were radiologic shadows in the spleen, splenoportal system, and a large part of the liver parenchyma. These shadows were evidently deposits of thorium salts (Thorotrast) that had been injected into this patient's vein 30 yr previously for the purpose of localizing a cyst. Owing to a lack of response following medication for jaundice, a laparotomy was performed and the following found: hypertrophied left liver lobe; hardened and wrinkled liver surface; hard and shrunken spleen; concretions containing $ThO_2$ along the splenic vein and the bile duct that corresponded to the opaque radiologic shadows; calcified hydatid cyst; and adenocarcinoma of the biliary duct system. The patient died one month later. The probable carcinogenic effects of Th salts in this case are discussed. (BBB)

**27127** ULTRA-VIOLET LIGHT AND SKIN CANCER. H. A. W. Klinkhamer (Gloeilampenfabrieken, Eindhoven, Netherlands). Med. Mundi, 9: 77-81(1963).

In man skin cancer is probably caused in the majority of cases by exposure to uv radiation. Exposure to uv radiation provides a probability for the occurrence of skin cancer. This probability is small, but is increased by each subsequent irradiation. In regions where a population of white stock on account of occupation or because of meteorological circumstances is exposed to intense uv radiation from the sun, the probability of developing skin cancer must, for people above 60 yr of age, be expressed in per cent. Referred to the whole of such a population, the incidence of skin cancer must be expressed as a few per million. Excessive exposure to the uv light of the sun can best be avoided by keeping out of the sun when it is near its highest position, i.e., about noon. This applies in particular to tropic and subtropic zones, and to temperate zones in the summer, when the sun also attains a fairly high position at noon. The increase in the natural probability of developing skin cancer caused by irradiation with artificial sources of uv light is negligible, provided that such irradiation is applied in moderation. (auth)

**27128** EFFECTS OF IRRADIATION ON THE GLUCOSE-6-PHOSPHATASE ACTIVITY OF THE LIVERS OF RATS KEPT WITHOUT FOOD. D. Bonsignore, C. Canonica, O. Sartori, and L. Lenzerini (Centro Applicazioni Militari Energia Nucleare, S. Piero a Grado, Italy). Minerva Nucl., 8: 39-41(Jan.-Feb. 1964). (In Italian)

The activity of glucose-6-phosphatase was studied in the liver of rats irradiated with 700 r of x rays. The animals were kept without food after irradiation. The enzymatic activity was considered as a specific and as a total activity. The specific activity increased only in the fasting animals and not in the irradiated ones. There was no difference in the behavior of the total activity between the two groups of animals. (auth)

**27129** EFFECT OF WHOLE-BODY IRRADIATION ON THE RATE OF INCREASE OF BLOOD UREA NITROGEN FOLLOWING BILATERAL NEPHRECTOMY IN RATS AND RABBITS. Miles Fox and M. F. A. Woodruff (Univ. of Edingburgh). Nature, 202: 918-19(May 30, 1964).

It was found that whole-body irradiation to clinical doses prior to renal transplantation will greatly affect the rate of accumulation of urea in the blood stream even if the graft remains for a time completely anuric. (R.E.U.)

**27130** CORRELATION BETWEEN DEOXYRIBONUCLEIC ACID SYNTHESIS AND MORTALITY FOLLOWING IRRADIATION IN MICE. J. L. Sanders, Glenn V. Dalrymple, and C. D. Robinette (Univ. of Colorado, Denver). Nature, 202: 919-20(May 30, 1964).

A correlation between synthesis of DNA in the spleens of irradiated male mice (C57BL) and mortality results for the same strain is presented. The uptake of tritiated thymidine served as a measure of DNA synthesis. (R.E.U.)

**27131** RELATIVE RADIOSENSITIVITIES OF THE MATERNAL REPRODUCTIVE TRACT AND THE FERTILIZED OVUM. Melvin M. Ketchel and Upendra K. Banik (Worcester Foundation for Experimental Biology, Shrewsbury, Mass.). Nature, 202: 1021-2(June 6, 1964).

Complete loss of pregnancy in rats was caused by exposure of the female to 800 r x radiation on the first day of pregnancy. This loss appeared to be caused by the failure of the maternal reproductive tract. Some of the irradiated ova developed when transferred to a pseudopregnant nonirradiated rat. (C.H.)

**27132** EXPERIMENTAL RADIATION DAMAGE OF THE RETINA. Setsuko Shimizu (Nagoya Univ., Japan). Nippon Ganka Gakkai Zasshi, 67: 380-90(May 1963). (In Japanese)

The effect of x radiation on the retina of adult rabbits and mice was investigated both histopathologically and histochemically. The single eye or head of the animal was exposed to doses of x radiation from 1,000 to 10,000 r. The histopathological changes 24 hr after x radiation exposure included degeneration of the visual cell layer observed in the rabbits and mice exposed to doses of 3,000 to 4,000 r; outer layer damage by doses of 6,000 r; and histochemical changes in the rabbit retina. PAS reaction in the visual cell layer was increased by doses of 2,000 r or more; and PAS reaction in the outer layer was increased by a dose of 4,000 r. Alkali phosphatase reaction was increased in the damaged retina by doses of 2,000 r and it was quite similar to the effect observed on PAS reaction of the rabbit retina. Acid phosphatase reaction was increased in the outer layer 5 days after irradiation at a dose of 6,000 r. The methyl green pyronin reaction and the succinic dehydrogenase reaction were decreased with the progress of radioinduced retinal damages. (auth)

**27133** HISTOCHEMICAL STUDIES ON THE ACTION OF $\beta$-RAY IRRADIATION TO THE CONJUNCTIVAL EPITHELIAL CELLS. 5. SUMMARY OF ALL THE REPORTS. Nobuhiko Matsuo (Okayama Univ., Japan). Nippon Ganka Gakkai Zasshi, 67: 596-600(Aug. 1963). (In Japanese)

After irradiation of the palpebral conjuctiva of rabbits with $^{90}Sr$ $\beta$ rays at a rate of 5400 rep/min for 1, 5, 10, 15, 30, and 60 min, changes of the succinic dehydrogenase system, ketoenolic substances, and Feulgen's reaction were studied histochemically in the conjuctival epithelial cells. Changes in the fine structure of the cells were also examined with an electron microscope. The activity of succinic dehydrogenase decreased after irradiation; the longer the exposure, the more marked the decrease was. Ketoenolic granules decreased with the irradiation time up to 30 min, then increased after the 60-min period. Ketoenolic lipids decreased after the 1-min irradiation, increased after 10- to 15-min irradiation, and again decreased after the 30- to 60-min irradiation. DNA, as seen by the Feulgen reaction, decreased with the irradiation time. Intensifica-

tion of pyknosis paralleled the irradiation time. The nucleus showed more obvious changes than the mitochondria with brief irradiation but marked changes appeared in both nucleus and mitochondria with longer irradiation. The changes in DNA synthesis and the electron transport system were considered important in explaining the mechanism of the effects of $\beta$ rays. It was speculated that the organic peroxides that may be produced in the cells play an important role in the changes in DNA and the electron-transport system. (BBB)

**27134** RELATION BETWEEN THE OCCURRENCE OF ARCUS SENILIS OF THE CORNEA AND THE CONDITIONS AT EXPOSURE TO AN ATOMIC BOMB. I. Hirose (Nagasaki Univ.). Nippon Ganka Kiyo, 13: 652(Dec. 1962). (In Japanese)

The occurrence of arcus senilis of the cornea was studied in human subjects who had been exposed to atomic bombing. They were divided into four groups in accordance with the distance from the hypocenter. The first group consisted of 261 cases which showed symptoms of acute radiation sickness, and which had been exposed within 2000 m of the hypocenter; the second group consisted of 246 cases without acute radiation sickness exposed within 2000 m; and the third group consisted of 258 cases exposed within 3000 to 4000 m. The fourth group was composed of 241 cases with no history of exposure. The occurrence of arcus senilis of the cornea groups was 41.35%, 34.55%, 43.02%, and 48.13%, respectively. Thus no marked difference was found in the occurrence of arcus senilis of the cornea between the exposed cases and nonexposed cases. (BBB)

**27135** HETEROZYGOUS EFFECTS OF RADIATION-INDUCED MUTATIONS ON VIABILITY IN HOMOZYGOUS AND HETEROZYGOUS GENETIC BACKGROUNDS IN DROSOPHILA MELANOGASTER (PRELIMINARY REPORT). Terumi Mukai and Isao Yoshikawa (National Inst. of Genetics, Misima, Japan). Nippon Idengaku Zasshi, 38: 282-7 (Jan. 1964).

Heterozygous effects of mutations induced by low doses of x irradiation on viability were tested both in otherwise homozygous genetic background and in heterozygous genetic background in Drosophila melanogaster. On the basis of counting approximately 1.46 million flies, it was found that radioinduced mutations that occurred in homozygous genetic background were heterozygously beneficial to their carriers, while those induced in hybrids between individuals originated from two unrelated populations were slightly detrimental to their carriers. (auth)

**27136** ON THE FRACTIONAL- AND WHOLE-BODY MUTATIONS INDUCED BY SOFT X-RAYS IN DROSOPHILA. Y. Matsudaira, T. Ito, T. Yamasaki, S. Ishizaka, and M. Domon (Rikkyo Univ., Tokyo). Nippon Idengaku Zasshi, 38: 288-9(Jan. 1964).

Two-day-old male Oregon-R Drosophila were exposed to doses of 400, 720, and 1440 r monochromatic x radiation and mated with virgin females carrying four genetic markers. $F_1$ females were examined for the presence of ywm and f marker genes. The results showed that in the dose range used single locus mutants were more numerous than whole body mutants. (C.H.)

**27137** EFFECTS OF IMMERSION OF WINTERING BUD OF MULBERRY IN THE $^{32}P$ SOLUTION ON THE POLLEN MOTHER CELLS. Isao Tojyo. Nippon Sanshigaku Zasshi, 32: 108-12(Apr. 1963). (In Japanese)

Terminal bud cuttings of mulberry, which had been held in a dormant state by cold, were immersed in $^{32}P$ solution for two to six days. Bud development was delayed in the treated cuttings and abnormalities were observed in pollen. Chromosome aberrations induced by the radiation exposure are described. (C.H.)

**27138** ON THE EFFECTS OF IONIZING RADIATION EMITTED FROM $^{60}Co$ UPON THE DEVELOPMENT OF ASCARIS EGGS. REPORT I. STUDIES ON THE RELATION BETWEEN DOSE RATE AND ITS INHIBITORY EFFECTS UPON THE DEVELOPMENT OF EGGS. Yoshishiro Soeno (Nihon Univ., Japan). Nippon Univ. J. Med., 3: 283-300(1961).

Observation was made on the developmental condition of Ascaris suum eggs irradiated with 10 kC $\gamma$ rays from $^{60}Co$. Irradiation was performed at four dose rates $3.2 \times 10^4$/hr, $8.8 \times 10^4$ r/hr, $1.9 \times 10^5$ r/hr, and $6.4 \times 10^5$ r/hr, while the dose of $\gamma$ rays was maintained constant ($1 \times 10^5$r). The results showed that irradiation retards the development of the eggs. The delay of development may be based on delayed cleavage of cells. Such a delayed cleavage manifested itself on the fourth day of irradiation. The greater the dose rate, the more powerful such an effect was. (auth)

**27139** ON THE EFFECTS OF IONIZING RADIATION EMITTED FROM $^{60}Co$ UPON THE DEVELOPMENT OF ASCARIS EGGS. REPORT II. STUDIES ON THE RELATIONSHIP BETWEEN IRRADIATION DOSE AND ITS INHIBITORY EFFECTS UPON THE DEVELOPMENT OF EGGS. Yuji Kumagai (Nihon Univ., Japan). Nippon Univ. J. Med., 3: 301-20(1961).

Irradiation with $\gamma$ rays from $^{60}Co$ at doses of $10^4$, $10^5$, $1.3 \times 10^5$, $2.0 \times 10^5$, $3.0 \times 10^5$, $4.0 \times 10^5$, $5.0 \times 10^5$, $6.79 \times 10^5$, and $1.35 \times 10^6$ r inhibited the subsequent development of Ascaris eggs. The extent to which the development of the eggs was inhibited was related to irradiation dose. The great majority of Ascaris eggs died when they were irradiated with $\gamma$ rays from $^{60}Co$ at a dose of more than 5.0 to 10 r. (auth)

**27140** STUDIES ON FAVOURABLE EFFECT OF POST-RADIATION BLEEDING ON HEMATOPOIESIS AND SURVIVAL. V. THE EFFECT OF POSTRADIATION BLEEDING ON ERYTHROPOIESIS AND SURVIVAL OF RABBITS IRRADIATED WITH 1,000 r OF X-RAYS. S. Hajdukovic, M. Dragic, and V. Grujic (Institut za Nuklearne Nauke "Boris Kidric," Belgrade). Nucl. Hematol., 3, XI-XII (June-Aug. 1964).

The effects of post-irradiation bleeding on hematologic regeneration and survival in rabbits was investigated. It was found that bleeding of 40% of total blood volume has no harmful effect on radiation sickness. Bleeding causes deeper post-irradiation anemia, which develops spontaneously after irradiation. Analysis of erythrocytes, hemoglobin, and hematocrit showed that strong animals treated that way regeneration in peripheral blood starts with the 4th post-irradiation day, followed with decrease on the beginning of the second week and then with intensive erythroid regeneration on the 12th post-irradiation day. All the results showed that post-irradiation bleeding has a stimulative effect on erythroid regeneration of rabbits irradiated with 1000 r of x rays. As a consequence of stimulated erythroid regeneration the greater survival of animals (40 %) in 30 days post-irradiation period is found after the doses that killed all control animals. (P.C.H.)

**27141** STUDIES ON FAVOURABLE EFFECT OF POSTRADIATION BLEEDING ON HEMATOPOIESIS AND SURVIVAL. VI. INCORPORATION OF $Fe_{59}$ IN PERIPHERAL BLOOD, BONE MARROW, LIVER AND SPLEEN OF RABBITS IRRADIATED WITH 1,000 rX. M. Dragic, S. Hajdukovic, and V. Grujic (Atomic Energy Agency, Vienna). Nucl. Hematol., 3: XIII-XV(June-Aug. 1964).

In irradiated and irradiated and bled rabbits studies were made on: the dynamics of the incorporation of $^{59}Fe$ in the peripheral blood erythrocytes between the 10th and 30th day of post-irradiation; 24 hr incorporation of $^{59}Fe$ in the peripheral blood erythrocytes on the 3rd, 6th, 9th, and 12th day after the treatment; and the incorporation of $^{59}Fe$ in the bone marrow, liver, and spleen. The results showed that on the 10th day the incorporation of $^{59}Fe$ in the peripheral blood erythrocytes of irradiated and bled animals is much higher than the incorporation in irradiated animals. This indicates not only that the regeneration of the red cell strain has begun but also that it is more intensive in R + A animals. On the basis of the results obtained for the 24 hr incorporation of $^{59}Fe$ in the peripheral blood and its distribution in the bone marrow, liver, and spleen, it was concluded that the red cell regeneration in irradiated and bled animals begins between the 6th and 9th day following the beginning of the treatment. However, this is not the case in animals irradiated only. (P.C.H.)

**27142** BIOLOGICAL EFFECTS OF IONIZING RADIATION. M. Fraccaro and L. Tiepolo (Università, Pavia, Italy). Pathol. Biol. Semaine Hop., 11: 1171-78(1963). (In Italian)

The mode of action of ionizing radiations, their effects on functions and cellular structures and effects on the synthesis of DNA, of RNA, and of proteins are discussed. It is pointed out that radioinduced mutations can be due to effects on chromosomes or genes. These two categories are examined separately. Particular attention is paid to the problem of the differences of sensitivity of the gametic cells in the various stages of their development in the light of experimental work on Drosophila and mice. The problem of chromosomal anomalies induced by radiation in cells of mammals in tissue culture is examined. The question of the genetic effects of radiation in man is discussed, with emphasis on methodological difficulties. (auth)

**27143** POSSIBLE APPEARANCE OF LEUKEMIAS FOLLOWING THERAPEUTIC OR DIAGNOSTIC USE OF IONIZING RADIATIONS. Dozena Leszko and Halina Zdziechowska (Hematology Inst., Warsaw). Polski Tygod. Lekar., 17: 1300-2(Aug. 13, 1962). (In Polish)

The literature relating to the postirradiation development of leukemia is reviewed, and 10 new cases are reported in which leukemia developed two to 18 yr following radiotherapy (8 cases) or diagnostic radiology exposure (two cases). In three cases the leukemia was of the acute myeloid type, in six of the chronic myeloid type, and in one of the chronic lymphoid type. In three cases, men aged 36, 38, and 45 yr developed chronic myeloid leukemia two, five, and six yr, respectively, after therapeutic spinal irradiation for ankylosing spondylitis; only in the first case was the radiation dose known (5500 r). In two other cases, women aged 54 and 57 yr incurred chronic and acute (respectively) myeloid leukemia 11 and 4 yr following x-ray treatment (recorded dose in the second case, 2100 r) for polycythemia vera. The sixth case concerns a 59-yr-old woman treated for uterine carcinoma 7 yr earlier with 12,000-r pelvic x irradiation and 18.48 mC intracavitary Ra who developed chronic myeloid leukemia. In the seventh case a 50-yr-old woman was diagnosed as having acute myeloid leukemia 3 yr after 15,900-r irradiation for mammary carcinoma. In the eighth patient, a 38-yr-old woman, an unknown dose of radiation was used to treat cervical lymphadenopathy 18 yr before she was found to have acute myeloid leukemia. The ninth and tenth cases, men aged 29 and 42 yr, had undergone repeated chest roentgenography (doses unknown) for pulmonary tuberculosis seven and four yr prior to developing chronic myeloid and chronic lymphatic leukemia, respectively. Other data relating to these patients' case histories are supplied, and a discussion is presented of the possible leukemogenic action of radiation, from which it was concluded that, until further information is available, radiotherapy and radiodiagnosis should be used with great caution. (BBB)

**27144** THE EFFECT OF X-RAYS ON THE DEVELOPMENT OF A FETUS. Roman Borkowski and Eugeniusz Szczepanik. Polski Tygod. Lekar. Wiadomosci Lekar., 17: 391-4(1964). (In Polish)

The danger of post-irradiation somatic and genetic lesions is discussed. The results of experimental and clinical investigations are presented and the means of avoiding, or at least decreasing, the injurious effects of x rays on fetuses are given. (auth)

**27145** TAURINE EXCRETION FOLLOWING DRUG-INDUCED MUSCLE NECROSIS AND X-IRRADIATION. R. A. Goyer, M. W. Yin, and D. H. Bowden (St. Louis Univ.). Proc. Soc. Exptl. Biol. Med., 116: 534-6(June 1964).

Similar increases in urinary excretion of taurine were observed in rats following drug-induced muscle necrosis and x irradiation. The excess taurinuria appeared to be unrelated to altered renal function but is probably a nonspecific manifestation of increased tissue catabolism. (auth)

**27146** HISTOMORPHOLOGICAL CHANGES OF THE THYROID GLAND IN THE ACUTE RADIATION-SICKNESS. M. Podil'cak and P. Kal'niuk (Chair of General Surgery and Pathological Anatomy, Medical Inst., Lvov). Radiobiol. Radiotherap., 5: 51-62(1964). (In German)

Histological and histochemical changes of the thyroid gland were examined as to their dynamic development in acute radiation sickness. Three to 6 days after a single whole-body irradiation of rabbits with a dose of 800 r an increase in the height of follicular epithelium and an increase in the ribonucleic acid concentration in the cytoplasm were seen. The colloid gave an intense positive PAS-reaction. The phospholipids were uniformly distributed and were present in middle concentration. In the interstice a diffuse edema was found in different sections and there were no uniform plethora of the vessels and capillaries. In some vessels a swelling of the endothelium was found. The changes indicate an increased function of the organ in the first days after whole-body irradiation. At the climax of radiation sickness, a decrease in ribonucleic acid content in the cytoplasm of the follicular epithelium was found as well as diminished and nonuniform PAS-diazo body and Millon reactions. The histochemical changes took place at the bottom of markedly destructive and necrobiotic changes of stroma and follicles of the thyroid gland. The results obtained indicate a throttle of the thyroid function at the climax of acute radiation sickness. Regenerative features in the morphological picture and the histochemically examined substratum were seen 40 to 60 days after beginning the experiment. (auth)

**27147** THE OXIDATIVE PHOSPHORYLATION OF ISOLATED MITOCHONDRIA AFTER IRRADIATION. H.-J. Altenbrunn (Robert-Rössle-Klinik, Berlin). Radiobiol. Radiotherap., 5: 63-70(1964). (In German)

High radiation doses did not effect an uncoupling of respiration and phosphorylation in isolated mitochondria. Even the addition of uncoupling poisons caused no labilization of phosphorylation by irradiation. In the functionally labile mitochondria of the radiosensitive organs ionizing

radiation caused an accelerated aging. After whole-body irradiation, decreased P/O-quotients were observed in the mitochondria of radiosensitive organs. This effect was not caused immediately but in the course of a latent period. (auth)

**27148** THE CONTENT OF DIPHOSPHORPYRIDINE-NUCLEOTIDE IN ORGANS AFTER IRRADIATION. H.-J. Altenbrunn (Robert-Rössle-Klinik, Berlin). Radiobiol. Radiotherap., 5: 77-82(1964). (In German)

The DPN-concentrations of hepatic, splenic, and gonadal tissue of male rats were determined 0 to 48 hr after whole-body irradiation with 500, 10,000, and 25,000 r and compared with DPN-concentrations obtained after irradiation of lymphosarcoma-ascites in vitro and in vivo. It was demonstrated that the DPN-concentration in the organs of rats after irradiation with 10,000 r decreases by 10 to 15% in the liver and by 40% in the testis, the DPN-concentration being lower immediately after irradiation than after 24 hr. The DPN-concentration of lymphosarcoma- ascites decreased with irradiation in vivo also by about 30% in contrast to irradiation in vitro where shortly after irradiation a decrease in concentration of 65% was observed. (auth)

**27149** DATA ON THE RADIOMIMETIC EFFECT OF LOST — FUNCTIONAL CHANGES OF THE SUPRARENALS IN THE CASE OF POISONINGS BY LOST. G. David and D. Tanka (National Inst. for Rheumatism and Science of Bath Healing, Budapest). Radiobiol. Radiotherap., 5: 83-90(1964). (In German)

An investigation was made of the content of corticosterone of the suprarenal blood of rats poisoned by a $DL_{50/30d}$ dose of Lost (tris (2-chlorethyl)-amine-HCl:), 1.7 mg/kg, and the suprarenal ability of synthesizing corticosterone of the poisoned animals. It was found that the poisoning caused a functional change resembling those which were observed in the case of radiation sickness. The changes, however, appeared quicker and more severe. This confirms the radiomimetic effect of Lost and focuses attention on the different dynamics of the development of these two diseases. Concerning the biological and biochemical examinations, however, it was found that a connection between the morphological picture and the function was not seen and there was no parallel in the case of radiation sickness. (auth)

**27150** THE INFLUENCE OF SERUM OF IRRADIATED RATS ON THE JENSEN-SARCOMA IN VITRO. II. COMMUNICATION: THE INFLUENCE OF TUMOUR GROWTH BY SERUM OF FRACTIONATEDLY AND LOCALLY IRRADIATED RATS. H. Wagner (Humboldt-Universitat, Berlin). Radiobiol. Radiotherap., 5: 91-5(1964). (In German)

Albino rats were locally and fractionatedly irradiated with low energy x rays. The blood serum taken at different times after irradiation was tested with tissue cultures of Jensen sarcoma. The results showed this serum produced an inhibition or promotion of biological activity of the tumor, dependent on the time it was obtained and on the radiation dose. (auth)

**27151** CHRONIC X-RAY DERMATOSIS IN THE FACE WITH CANCERATION FOLLOWING VERY SOFT X-IRRADIATION. A. Kuta (Charles Univ., Prague). Radiobiol. Radiotherap., 5: 137-45(1964). (In German)

Two cases of low grade chronic x ray dermatosis of the face are reported which developed after a combined actinotherapy. In both cases some basaliomatous focuses arose. In a third case a spinalioma of the thumb developed. It is stressed the pronounced precancerous nature of this slight x-ray exposure of the skin points to the relatively frequent incidence of basocellular proliferations in this region and emphasizes the necessity of preventive measures. (auth)

**27152** THE INHOMOGENEITY OF THE GRID FIELD FOLLOWING INTENSIVE RADIATION THERAPY OF BRONCHIAL CARCINOMA — ROENTGENOGRAPHY OF THE COURSE OF RADIATION PNEUMONITIS. R. Schoeneich (Bezirks-Krankenhauses, Cottbus, DDR). Radiobiol. Radiotherap., 5: 163-70(1964). (In German)

Observations of radiation pneumonitis corresponding to the holes of the irradiation grid are reported on these cases. In two cases it was the radiation response after still dose single grids of two opposite fields with 4000-r incident dose each. In the third case it was found with fractionated grid irradiation of 800-r incident dose, given nine times for each field following operated bronchial carcinoma. (auth)

**27153** QUANTITATIVE CHANGES OF NUCLEIC ACIDS OF ESCHERICHIA COLI AFTER IRRADIATION. F. Szeszak, A. Jeney, F. Hernadi, and T. Valyi-Nagy (Medical Univ., Debrecen, Hungary). Radiobiol. Radiotherap., 5: 217-22(1964). (In German)

X-ray-induced changes were investigated in the Ph content of E. coli B. cell fractions. The value of RNA-P as well as of DNA-P was decreased by irradiation while the P-content of the acid-soluble fraction increased. After separation of the acid-soluble fraction an increase of all the mononucleotide and pentose-phosphate components was observed. All these changes occurred in specimens that were kept for 30 min at 21°C and were considered secondary. (auth)

**27154** THE EFFECT OF X-RAY AND ULTRAVIOLET IRRADIATION ON THE BUDDING OF YEAST-CELLS (SACCHAROMYCES CEREVISIAE) FOLLOWING IRRADIATION. T. Ganti and E. Nagy (Medical Radiological Research Group, Academy of Sciences, Budapest). Radiobiol. Radiotherap., 5: 223-32(1964). (In German)

Radioinduced changes in the reproductive cycles in synchronous cultures of Saccharomyces cerevisiae were examined after exposure to x and uv rays. The single irradiations were given in the different intervals of time of the so-called lag phase. After uv irradiation the synchronity degree and the number of cells which were capable of budding decreased. No effect was seen if the irradiation was given directly before budding began. In the case of x irradiation, only a temporary shift in the growth curve was observed, the manifestation of which required a certain interval of time. (auth)

**27155** FURTHER STUDIES ON THE IMMUNOLOGIC SPECIFICITY OF IRRADIATED SERA. A. Aureggi, G. Pittoni, and L. Ravaioli (Istituto Superiore di Sanita, Rome). Rend. Ist. Super. Sanita, 25: 395-406(1962). (In Italian)

The effect of in vitro irradiation of serum on antigenicity of its protein components was investigated. Horse serum was exposed to 10,000- to 150,000-r doses of $^{60}Co$ $\gamma$ radiation, and tested for its ability to stimulate antibody formation and elicit anaphylaxis in guinea pigs. The reinjection of 150,000-r irradiated serum into guinea pigs sensitized with nonirradiated serum caused anaphylactic death in only 4% of the animals compared with 64% of controls, although 84% showed slight, transient symptoms of anaphylaxis. In contrast, in animals sensitized with 150,000-r irradiated serum, fatal anaphylaxis could be elicited with normal horse serum in 50% of the animals. It is postulated that radiation alters only superficially some complex antigens, the protein molecule being considered as having both superficial and internal antigenic components. A medium radia-

tion dose of 75,000 r acting on the eliciting serum reduced the anaphylatic deaths only to 40%, and 10,000 r gave a rate (61%) similar to that of nonirradiated serum. When 150,000-r irradiated horse serum was used for both the sensitizing and eliciting injections, the mortality rate (60%) was also similar to that of controls. The irradiated serum, when examined by paper electrophoresis, showed a decrease in the albumin/globulin ratio that was proportional to the dose; the 150,000-r dose reduced it to 0.72 from a normal value of 0.83. (BBB)

**27156** RENAL HOMOTRANSPLANTATION IN MAN WITHOUT CONSANGUINITY. SURVIVAL UP TO THE 17th MONTH. R. Kuess, M. Legrain, G. Mathe, R. Nedey, and Camey (Centre Medico-Chirurgical Foch, Suresnes, [France] and Institut Gustave-Roussy, Villejuif, France). Rev. Franc. Etudes Clin. Biol., 1048-66(Dec. 1962). (In French)

A partially successful attempt is reported of a human kidney homotransplant in which there was no consanguinity between the donor and recipient (brother-in-law to sister-in-law), who suffered from chronic pyelonephritis. The homotransplant functioned until the beginning of the 17th month. Initially the transplanted kidney functioned well, but at the 7th week an episode of severe functional impairment occurred which was partially reversed by treatment. Function then remained constant from the 3rd to the 9th month, with a slow progressive impairment from then up to the 17th month. Preliminary to transplantation the recipient received whole-body irradiation of 400 rad plus 200 rad locally to the spleen from a $^{60}$Co source at the Gustave Roussy Institute. At the 7th week the renal functional impairment was treated with a further whole-body irradiation of 100 rad, local irradiation of the transplanted kidney, as well as 6-mercaptopurine and steroid therapy. Finally an intermittent treatment with 6-mercaptopurine and steroid was given and during the latent phase an attempt at conditioning was tried with blood transfusions from the donor. The part played by pretreatment or conditioning in the prolonged tolerance is discussed. It is suggested that the partial success in this case offers substantial hope that high-dosage irradiation, with other possible adjuncts, will eventually permit permanent survival of renal homografts. (BBB)

**27157** NEW REFLECTIONS ON THE USE OF IONIZING RADIATIONS IN MEDICINE. Paul C. J. Roth (Museum National d'Histoire Naturelle, Paris). Rev. Pathol. Gen. Physiol. Clin., 63: 484-92(Apr. 1963). (In French)

Criticisms are advanced against the excessive use of radiation in medicine for diagnostic and therapeutic purposes, with reference to the literature on this subject. The survey shows that cancer of the thyroid, at one time rare in children, became the most frequent type of cancer particularly between 1945 and 1957. Over 80% of patients had a history of being irradiated in early infancy for hypertrophy of the thymus, tonsils, adenoids, or for moles and angiomas. At diagnosis only 23% had localized tumors of the thyroid; in the remainder metastases were present. It appears that infant thyroid cells are sensitive to stimuli that affect adult cells only very slightly. Latency periods vary between 3 and 17 yr. Three children are cited who had received irradiation for eczema while under a year old. It was estimated that approximately 25% of radiologic treatments at all ages are given for nonmalignant conditions. Added to this are clinical experiments, such as use of albumin labeled with $^{131}$I, which in one study was introduced into a brachial vein of 60 atherosclerotic patients for the purpose of determining blood flow rate in the leg. In another study in 17 normal children age 3 to 9 yr, the metabolic rate of $^{131}$I, labeled thyroxine was determined. It is concluded that later human generations will be increasingly exposed to radionuclides and chemical carcinogens distributed in the biosphere, by an ever-developing and poorly controlled industry, in our surroundings, and to ionizing radiations which modern medical practice will deliver before birth, at times in early infancy, and systematically thereafter throughout childhood and adolescence. (BBB)

**27158** CHANGES IN THE SERUM PROTEINS OF MICE AFTER LETHAL IRRADIATION. P. Grabar, K. P. Kashkin, and J. Courcon (Institut Pasteur, Paris). Rev. Franc. Etudes Clin. Biol., 8: 565-9(1963). (In French)

Electrophoretic and immunoelectrophoretic analyses were applied in studies on changes in serum proteins of mice induced by exposure to 1000 r x radiation. The total serum proteins fell about 15% by the second day after irradiation but returned to approximately normal levels by the 6th day and remained at such values until death. Globulin fractions were affected most by this radiation dose. (C.H.)

**27159** ON ROENTGEN CATARACTS. Y. Masuda, K. Kimura, and T. Mikawa (Kurume Univ., Japan). Rinsho Ganka, 17: 147-51(Feb. 1963). (In Japanese)

Lens opacity is described in a man who had received ocular irradiation 12 yr earlier for treatment of conditions affecting the retina and vitreous body. The total dose was 3000 r given over three months to the left eye. Visual impairment of the left eye was his chief complaint. At the time of examination, visual powers were 0.3 and 0.04 for the right eye and the left, respectively. Using a slit lamp microscope, an opaque lesion of the posterior pole of the posterior subcapsular layer appeared to be finely granular, vacuolar, and disc-shaped. The opacity was greater in the left eye than in the right. The histologic findings of left crystalline lens after intracapsular extraction showed a tendency of thickening in the posterior capsule at the posterior pole and hyaline degeneration in other parts of the capsule. Under the capsule, vacuolation and hyaline degeneration were observed. The nuclei of the epithelium were pycnotic. The anterior capsule was almost normal. (BBB)

**27160** CHANGES OF THE PERIPHERAL BLOOD AFTER PARENTERAL APPLICATION OF RADIATING SUBSTANCES. II. THE EFFECT OF RADIOGOLD ($^{198}$Au). Z. Dienstbier and F. Vitek (Charles Univ., Prague). Sb. Lekar., 64: 193-201(July 1962). (In Czech.)

Changes in peripheral blood after intravenous application of colloidal $^{198}$Au were studied. The isotope was given to rats in doses of 0.29, 1.16, 4.64, 6.95, and 11 $\mu$C/g body wt. The most conspicuous change observed was lymphopenia, which was lowest one week after application. Neutropenia was mush less marked. The occurrence of reticulocytosis, observed after injection of $^{32}$P, was also seen after injection of $^{198}$Au. On the basis of the experimental finding that 4 hr after injection 75% of the isotope is stored in the liver, for the above-mentioned quantities of applied radioisotope, the absorbed dose of radiation in a critical organ as well as in the body as a whole was calculated. The clinical application of radiogold is discussed, and its slight noxious effects on hematopoiesis are emphasized. (BBB)

**27161** SENSITIVITY OF THE HEAD TO X-RAY. J. Garcia, N. A. Buchwald, B. H. Feder, R. A. Koelling, and L. Tedrow (Veterans Administration Hospital, Long Beach, Calif.). Science, 144: 1470-2(June 19, 1964).

Rats were trained to respond to signals consisting of very low doses of x ray directed to the head. This stimulus is probably received in the vicinity of the olfactory bulbs and adjacent neural structures. (auth)

**27162** THE INFLUENCE OF X-RAY IRRADIATION UPON SPHERICITY OF ERYTHROCYTES IN VIVO. Kaichiro Kuroda, Masaaki Fujino, Takashi Murata, Hiroshi Kubo, Yorio Nakanishi, Yukiko Numata, Senyo Tokugawa, Goro Manabe, and Hidekazu Kinoshita (Tokushima Univ., Japan). Shikoku Igaku Zasshi, 19: 113-17 (Apr. 1963). (In Japanese)

The effects of whole-body exposure to doses of 250 or 500 r x radiation on the morphology of erythrocytes were studied in rabbits. Maximum changes in morphology were observed about 12 hr after exposure to 500 r. (C.H.)

**27163** ON THE EFFECTS OF GAMMA RAYS UPON THE DEVELOPMENT OF ASCARIS EGGS. Nobutane Mori (Nihon Univ., Japan). Sogo-Kaiyokagaku, 5: 1-12(Mar. 1963). (In Japanese)

The effects of $\gamma$ rays emitted from $^{60}Co$ upon the development of Ascaris eggs are described. Inhibitory effects of $\gamma$ rays upon the development of the eggs were very apparent. The irradiation retarded the development of eggs by causing delayed cleavage. Such effects were related not only to irradiation dose but also to dose rate. The greater the dose as well as the dose rate, the more pronounced was the effect. (C.H.)

**27164** SURFACE DOSES OF FAST ELECTRONS IN THE ENERGY REGION FROM 8 to 36 Mev. Klaus Wuerthner and Dietrich Frost (Rudolf-Virchow-Krankenhauses, Berlin). Strahlentherapie, 123: 503-7(Apr. 1964). (In German)

Surface doses of fast electrons as a function of energy and field size were measured using a lucite phantom with a thin-walled and flat ionization chamber. Using field sizes of 14 × 14 cm and 4 cm $\phi$ and an energy range from 13.9 to 36.1 Mev, the surface dose was 93% of the dose in the depth dose maximum. Using a large field (14 × 14 cm), the surface dose was 88% for 8.3 Mev and increased to 91% if a small field of 4 cm $\phi$ was used. (auth)

**27165** CONTRIBUTIONS TO THE DEVELOPMENT OF DOSIMETRY OF FAST ELECTRONS. PART 2. DOSE CONCEPTS AND THEIR REALIZATION. Benno Markus (Universität, Gottingen, Ger.). Strahlentherapie, 123: 508-33(Apr. 1964). (In German)

The function $Q_T dT$ for dose rates was calculated. Values for absolute and relative stopping probabilities for electrons at 5.6 kev to 46,288 Mev in air and water are given in tabular form. Electron spectra in water for various conditions are presented. Tests of the calculation method are given. Calculations for the relation of energy absorption per gram of medium to the ionization charge produced are also included. Methods of determining absolute doses in bones are described. Chemical, colorimetric, and calorimetric methods are also discussed. (M.C.G.)

**27166** ON THE GROWTH OF X-RAY IRRADIATED MALIGNANT MELANOMAS IN TISSUE CULTURES AND IN TRANSPLANTATION RESEARCH. I. RESEARCH ON HUMAN MALIGNANT MELANOMAS AND ANIMAL MELANOMAS AFTER SINGLE IRRADIATIONS. Bernward Rohde and Arthur Wiskemann (Universität, Hamburg). Strahlentherapie, 123: 534-44(Apr. 1964). (In German)

Even after fractionated small area irradiation of human melanomas with a total of 12000 r and single irradiation with 15000 r melanine-producing cells from the irradiated tissue can be induced to grow in tissue culture. Similar results were obtained after a single irradiation of the Harding-Passey melanoma of mice with up to 17500 r. The percentage of positive cultures, however, decreased from 55 to 15% between 5000 and 7500 r. While the non-irradiated Harding-Passey melanoma grew in 90% of the transplantation experiments, the growth rate decreased from 26 to 0% after single irradiation with 5000 to 10000 r. (auth)

**27167** TUMORS AS LATE INJURIES OF OFFSPRINGS OF WISTAR RATS AFTER WHOLE-BODY IRRADIATION ON THE 9th DAY OF PREGNANCY. Gert Wegner and Emil Heinz Graul (Universität, Marburg, Ger.). Strahlentherapie, 123: 609-13(Apr. 1964). (In German)

A 40% incidence of brain and eye malformations as well as 10% late tumor incidence were observed in the first generation of Wistar rats after total-body irradiation with 100 r at the 9th day of pregnancy. Malignant growths exceeded benign tumors. Benign tumors of the mamma were observed in normal autopsies of endocrine organs of the $F_1$-generation. There were no tumors on organs of internal secretion. The influence of endocrine organs upon the type of tumors is shown. The second generation showed no malformations, and there was no significant decrease of the life expectancy. An increase of tumor incidence could not be found in the animals of $F_2$ generation. The values observed were not different from the results obtained in control animals, which showed a spontaneous tumor rate of 3 to 4%. (auth)

**27168** RADIOGENIC DAMAGE OF BONES, THE BONE MARROW, AND VESSELS AFTER TELECOBALT IRRADIATION. PART I. EXPERIMENTS ON GUINEA PIGS IRRADIATED WITH 5000 r $^{60}Co$. Juergen Kollath (Strahlentherapeutische Klinik am Stadt. Krankenhaus Moabit, Berlin). Strahlentherapie, 123: 614-21(Apr. 1964). (In German)

Except for a sporadic and late appearing "osteocyte death," which was caused secondarily by damage to the vessels, a bone reaction can hardly be observed in radiotherapy using telecobalt sources. Thickening, hyalinization, and cell impoverishment were observed at the periosteum. The bone marrow became poor in cells and completely fibrosed in the irradiated area. The vessels showed a slight thickening of the intima. Obliteration of the vessels were not observed. (auth)

**27169** X-RAY CANCER 20 YEARS AFTER IRRADIATION OF A THORACIC WALL SARCOMA. Theodor Reinermann (Knappschafts-Krankenhauses, Recklinghausen, Ger.). Strahlentherapie, 123: 632-7(Apr. 1964). (In German)

The occurrence of an x-ray induced carcinoma 20 years after irradiation of a sarcoma of the thoracic wall is reported. Using clinical and experimental results reported in the literature about the radiation carcinogenesis, the development of the carcinoma is discussed. It was concluded that a so-called combination damage could have been present. (auth)

**27170** THE EFFECT OF IONIZING RADIATION IN THE EMBRYONIC AND FETAL STAGES. Arne Evensen (Rikshospitalet, Oslo). Tidsskr. Norske Laegeforen., 83: 950-3(June 1, 1963). (In Norwegian)

A survey of the literature on fetal injuries caused by ionizing radiation is given. It is emphasized that the radiation effects differ at various stages in pregnancy. Small doses of radiation given in the preimplantation period, when the fertilized eggs are still in the uterine tubes, may cause increased resorption of the eggs and decreased numbers in the litters. Malformations can also be induced in

this period. The greatest number of malformations, however, are seen when the fetuses are exposed to radiation in the period of organogenesis, and the number and degree of malformations increases with the dose. Certain deformities can only be induced within specific periods. Heavier radiation doses in the period of organogenesis provoke increased neonatal deaths and decreased weight and numbers in the litters. The injuries to the fetus caused by radiation during the period of growth are similar to the radiation injuries seen after birth, viz., anemia, intestinal injuries, edema, and local necrosis in different organs. Following irradiation in this period of the pregnancy, the number of neonatal deaths is greater than the number of prenatal deaths, and the shorter the interval from radiation to term, the fewer numbers of the litter will survive. It is also emphasized that women in the fertile period should only be exposed to therapeutic or diagnostic abdominal radiation when pregnancy can be excluded, i. e., during the first 10 to 12 days after the beginning of their last menstrual period. (BBB)

**27171** CELLULAR GROWTH AND TISSUE RADIOSENSITIVITY: TISSUE STUDIES IN VIVO AND THE CONCEPT OF RADIATION NEPHRITIS. John G. Maier (Walter Reed Army Medical Center, Washington, D. C.) and George W. Casarett. Trans. N. Y. Acad. Sci., 26: 599-627(Feb. 1964).

A study was made of the effects of single exposure, localized irradiation of the kidneys in beagle dogs at 500, 1,000, and 2,000 rad using 220 kv x ray. Both functional and morphological parameters were investigated, with animals being sacrificed at six months postirradiation. Unilateral and bilateral in situ kidney irradiation was given, as well as unilateral irradiation of single exteriorized kidneys. Morphological studies included excretory urograms and gross radiographs of kidneys perfused with an opaque mixture of lead oxide and gelatin at the time of sacrifice. Microangiographs were made of perfused kidneys. Autopsies were performed on all animals, and histologic studies were performed utilizing both routine and special staining techniques. On the basis of the present experiment and a consideration of the serial sacrifice experiments, it is concluded that irradiation of the canine kidney produces a progressive arteriolonephrosclerosis. The degree and rate of progression is related to the absorbed dose. At six months following irradiation, minimal arteriolonephrosclerotic changes were seen in the dog kidney receiving 500 rad, severe changes at 2,000 rad, and intermediate changes at 1,000 rad. (auth)

**27172** INCORPORATION OF RADIOMETHIONINE IN THE PROTEIN FRACTIONS OF THE SERUM UNDER THE EFFECT OF X-RAY IRRADIATION AND THIOPHOSPHAMIDE. I. V. Savitskiĭ and V. G. Zelinskiĭ (Odessa Medical Inst., Academy of Sciences, Ukrainian SSR). Ukr. Biokhim. Zh., 36: 14-21(1964). (In Ukrainian)

Studies were made on the serum proteins in rats and the incorporation of methionine $^{35}S$ in various fractions of serum proteins under the action of x rays, thiophosphamide, and the combination of these factors during the initial period after radiation. The procedure of investigation was based on electrophoresis combined with radioactive indication. X irradiation (600 r) led to a reduction in the total protein content of the serum and to an increase in methionine $^{35}S$ incorporation in all fractions of serum proteins. The conjunction of x irradiation and thiophosphamide led to a decrease in the quantity of total protein and to a reduction in the gamma globulin of the serum. The incorporation of methionine in all protein fractions was higher than in the control, but it was somewhat lower for the globulin fractions than with irradiation alone. The results obtained corroborate the previously advanced proposition that under conditions of combined action of ionizing radiation and chemical preparation the effect of each of these factors on the organism may be enhanced or attenuated. (auth)

**27173** COURSE OF EXPERIMENTAL (ALLOXAN) DIABETES IN IRRADIATED ANIMALS. S. A. Akopyan and M. A. Manukyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 11-16(1963). (In Russian)

Experiments on rabbits showed that 20 hr, following x irradiation, an injection of alloxan brought about a drastic worsening of general condition of the animals, leading to their death. Most of the irradiated animals died in 5 to 10 min, following the injection of an alloxan diabetic dose. In the case of an alloxan injection on the 7th day following irradiation, diabetes developed not so rapidly and the disease symptoms were of a more moderate character. (auth)

**27174** COMBINED EFFECT OF IRRADIATION AND BLOOD LOSS ON PHAGOCYTIC ACTIVITY OF LEUKOCYTES IN RABBITS. M. I. Alaverdyan, M. A. Movsesyan, and T. Kh. Marukyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 17-26(1963). (In Russian)

The effects of x rays and blood loss (both separately and in combination) on phagocytic activity of pseudoeosinophils, lymphocytes, monocytes, and basophils in the blood of rabbits were investigated. It is stated that a single total x irradiation (800 r) of the animals was followed by an increase of the pseudoeosinophil absorbability 24 hr after irradiation and by a decrease of the phagocytosis level on the 5th, 10th, and 15th days of the postirradiative period. The results obtained also showed that an acute blood loss (30% of the total volume of the circulating blood) in nonirradiated rabbits brought about no appreciable changes in phagocytic activity of pseudoeosinophils. Irradiation combined with a blood loss gave rise to a more drastic depression of phagocytosis. (auth)

**27175** EFFECT OF DIRECT CURRENT ON LABILITY OF BRAIN STRUCTURES IN RABBITS IN THE CASE OF RADIATION LESION. R. K. Arutyunyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 37-45 (1963). (In Russian)

A study was made of the effects of biocurrents of the optic cortex, subcortex, and reticular formation of the midbrain, with the brain being irritated by means of a dc anode and cathode, and irradiated with a dose of 700 r on rabbits with implanted electrodes. The purpose of the anodic and cathodic stimulation of the brain was to alter the initial and subsequent functional state of the brain structures in order to effect the radiation lesion. The experimental results showed that anodic current, giving rise to labilizing and normalizing effects, both prior to and after irradiation, reduces the degree of radiation lesion of the irradiated animals. Brain cathodization showed no similar effect. (auth)

**27176** EFFECT OF DECORTICATION AND X-RAY IRRADIATION UPON PHAGOCYTIC ACTIVITY OF LEUKOCYTES IN RABBITS. M. I. Alaverdyan, L. S. Gëzalyan, T. Kh. Marukyan, O. E. Terdzhanyan, and V. M. Okhikyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 47-52(1963). (In Russian)

It was found that decortication of rabbits and x irradiation of normal animals reduce phagocytic activity of leukocytes. (auth)

**27177** EFFICIENCY OF PROPHYLACTIC ACTIVITY OF SPECIFIC GAMMA-GLOBULIN IN THE CASE OF VAC-

CINE KERATITE IN IRRADIATED AND NONIRRADIATED RABBITS. L. A. Kamalyan and Zh. Ts. Vartevanyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 53-7(1963). (In Russian)

A study was made of an x-ray effect (700 r) upon the efficiency of serum prophylactics in the case of vaccine keratite in rabbits. The experiments showed that irradiation increased the sensitivity to the vaccine virus and decreased the efficiency of serum prophylactics. The course of the infection process in irradiated rabbits was characterized by greater severity. (auth)

**27178** A COMPARATIVE STUDY OF VACCINE VIRUS REPRODUCTION IN X-RAY IRRADIATED AND NONIRRADIATED TISSUE CULTURE. L. A. Kamalyan, Zh. Ts. Vartevanyan, and E. L. Shakhnazaryan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 59-64(1963). (In Russian)

A study was made of the effect of x irradiation (10 kr) on virus reproduction in the dermomuscular tissue of a chicken embryo. The experiments showed that infectious and hemoagglutinating properties of the vaccine virus undergo no significant changes in the course of six passages through the irradiated tissue culture. (auth)

**27179** LUMINESCENT MICROSCOPY METHOD TO EXAMINE A TISSUE CULTURE X-RAY IRRADIATED AND INFECTED WITH VACCINE VIRUS. L. A. Kamalyan and R. A. Ter-pogosyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 65-9(1963). (In Russian)

A luminescent microscopy method was applied in examinations of tissue culture, x irradiated (20,000 r) and infected with a vaccine virus. Acridine orange was used for fluorochroming the preparations. Alterations in the nature of luminescence of the nucleus nucleproteins and the cytoplasm showed certain differences in the way the virus and x rays affect the tissue culture. The experiments revealed drastic disturbances in the cells subjected to a combined effect of the factors examined. (auth)

**27180** EXAMINATION OF THE PHAGE T1 REPRODUCTION IN X-RAY IRRADIATED E. COLI B CELLS. R. A. Ter-pogosyan and A. T. Ter-avetisyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 71-6(1963). (In Russian)

An examination was made of the phage reproduction peculiarities in x irradiated microbe cells. The results obtained show that the phage $T_1$ reproduction in E. coli B cells irradiated with increasing x-ray doses (1 to 100 kr) was depressed. The extent of the depression of the phage reproductive capacity depended both on irradiation dose and on an after-irradiation period. The possibility was also shown to restore, by means of subsequent passages, the irradiation-reduced capacity to synthesize phage. The phage $T_1$ reproduction in E. coli B cells, isolated from x-irradiated (900 r) rabbits in various periods (3 to 10 days) after irradiation, was not changed. (auth)

**27181** A COMPARATIVE STUDY OF VACCINE VIRUS REPRODUCTION IN X-RAY IRRADIATED AND NONIRRADIATED TISSUE CULTURE. L. A. Kamalyan, R. A. Ter-pogosyan, and Zh. Ts. Vartevanyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 77-82(1963). (In Russian)

Vaccine virus reproduction in x-irradiated (20,000 r) tissue culture was studied. The results obtained showed a much greater accumulation of the infectious virus in the liquid fraction of the irradiated tissue culture compared to the nonirradiated one, 96 hr following the infection. (auth)

**27182** EFFECT OF IONIZING RADIATION ON CERTAIN IMMUNOBIOLOGICAL FUNCTIONS OF THE BLOOD AND RETICULO-ENDOTHELIAL SYSTEM (RES). E. D. Stepanyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 83-94(1963). (In Russian)

Experiments carried out on rabbits indicate that ionizing radiation and bacterial antigen used separately and jointly change the phagocytic capacity of the reticulo-endothelial system (RES) by two stages: at first they depress it for a short period of time and then stimulate it for a period of a longer duration. Simultaneously, antibody production is inhibited in irradiated rabbits but is stimulated in nonirradiated ones. It is also revealed that both phagocytic and antibody production capacities of the RES appear to function independently of each other. (auth)

**27183** EFFECT OF IRRADIATION DOSE INTENSITY ON ABSORBING AND ANTIBODY GENETIC FUNCTIONS OF THE RETICULO-ENDOTHELIAL SYSTEM. E. D. Stepanyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 95-100(1963). (In Russian)

The results of parallel experiments showed that under the influence of irradiation doses of various intensities the phagocytic activity of the reticulo-endothelial system changes in an undulatory manner: first it decreased and then increased. Antibody genetic function of the reticulo-endothelial system decreased, depending not so much on the dose magnitude as on its intensity. (auth)

**27184** EFFECT OF IRRADIATION SITE ON THE ACTION OF IONIZING RADIATION ON ABSORBING AND ANTIBODY GENETIC FUNCTIONS OF THE RETICULO-ENDOTHELIAL SYSTEM. E. D. Stepanyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 101-9(1963). (In Russian)

Experiments showed that phagocytic and antibody genetic functions of the reticulo-endothelial system change equally under both total and local effect of irradiation on the body. It is also evident that total and local effect of irradiation on the reticulo-endothelial system is determined by the neuroreflectory mechanism. (auth)

**27185** EFFECT OF CHRONIC ACTION OF STRONTIUM-90 ON CONTENT OF SUGAR IN THE BLOOD AND OF GLYCOGEN IN THE LIVER TISSUES. A. V. Fedorova and A. A. Mirzoyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 121-5(1963). (In Russian)

Variations in the content of sugar in the blood and of glycogen in the liver tissues due to the effect of $^{90}Sr$ in $8 \times 10^{-2}$-, $8 \times 10^{-3}$-, and $3 \times 10^{-3}$-$\mu$C doses were studied. White female rats were used in the experiments. The animals were subdivided into two groups, according to the dose used, with respective controls. It was shown that in the 1st and 2nd groups the increase of the sugar content in the blood, observed on the 10th day after introduction, was 34% and 11.9% higher compared to the controls. Later, both in the 1st and in the 2nd groups the sugar content decreased. No change of the sugar content in the blood of the 2nd group rats was observed. In the 1st, 2nd, and 3rd groups the decrease of the glycogen content in the liver was noted on the 10th day of introduction. Such hyperglycemia should be considered as the reaction of adaptation and compensation to the effect of irradiation. (auth)

**27186** EFFECT OF X-RAY IRRADIATION ON HISTAMINE CONTENT AND ON HISTAMINASE ACTIVITY IN THE BLOOD AND CERTAIN TISSUES. A. V. Fedorova and A. A. Mirzoyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 127-32(1963). (In Russian)

Experiments were conducted on white female rats weigh-

ing 160 to 180 g on the average. Histamine content in the blood and in various tissues as well as variations in histaminase activity were studied under the effect of a single dose (500 r) of x irradiation. The experiments reveal that following irradiation the histamine content changes differently in various organs. These changes are observed to develop faster in the skin. Two hours after irradiation the histamine content in the skin reaches its maximum. On the subsequent days a gradual decrease is noted and only on the 20th day the histamine content increases again, being nearly twice as high as the previous values. These changes develop more slowly in the kidney, liver, and brain. No significant changes of the histamine content in the blood due to x irradiation were observed. (auth)

**27187** CHANGES IN CALCIUM CONTENT AND IN ACTIVITY OF ALKALINE PHOSPHOTASE OF THE BLOOD SERUM UNDER CHRONIC EFFECT OF STRONTIUM-90. A. A. Mirzoyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 133-9(1963). (In Russian)

Changes in the blood serum Ca content and in the activity of phosphotase due to the chronic effect of various doses of $^{90}Sr$ were investigated in 200 female white rats weighing 160 to 180 g. The results showed that due to various doses of $^{90}Sr$ the blood serum Ca content decreased. This effect was most evident on the 20 to 30th days. This decrease amounted to 25% as against the control. Decrease of activity of the blood serum alkaline phosphotase was most evident due to a 1-$\mu$C dose on later dates. (auth)

**27188** EFFECT OF THE CEREBELLUM DAMAGE ON THE PERIPHERAL BLOOD OF IRRADIATED RATS. L. S. Gëzalyan and L. A. Gasparyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 151-7 (1963). (In Russian)

A partial destruction of the cerebellum brought about a prolonged disorder of the locomotor function and alterations in the blood system of rats. Appreciable disorders in the peripheral blood system were observed in the animals subjected to a combined effect of trauma and irradiation. (auth)

**27189** EFFECT OF IONIZING RADIATION ON VITAMIN $B_{12}$ LEVEL IN WHITE MICE. M. O. Pogosyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 159-63(1963). (In Russian)

An effect of single total irradiation (760 r) on the vitamin $B_{12}$ level in the liver, kidney, spleen, and intestine tissues in white mice was studied. One group of mice was irradiated with x rays, the other with $\gamma$ rays. The vitamin $B_{12}$ level was determined 1, 2, 4, and 7 days after irradiation. No vitamin $B_{12}$ deficiency was noted in the irradiated mice. When comparing the effects of x and $\gamma$ rays, there was observed a certain increase of the vitamin $B_{12}$ level in the aforenamed organs of the white mice irradiated with $\gamma$ rays. (auth)

**27190** EFFECT OF IONIZING RADIATION ON RHODOPSIN. A. A. Lalayan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 165-72(1963). (In Russian)

Some aspects of the effects of ionizing radiation effects on the retina-photosensitive pigment rhodopsin were studied. The experiments using a wide range of doses (50; 100; 500; 1,000; 5,000; 10,000; 20,000; 30,000; 40,000; 50,000 r) revealed that radiation gives rise to different effects, depending upon its intensity and dosage. It was shown that rhodopsin is the most radiosensitive when it is irradiated in the retina. A lowering of the optical density of the pigment is observed under the effect of much smaller doses compared with those cited in the literature, the fact testifying to its high radiosensitivity. (auth)

**27191** ON VVEDENSKY OPTIMIUM AND PESSIMUM PHENOMENA IN THE BRAIN CORTEX OF RABBITS SUFFERING FROM RADIATION LESION. R. K. Arutyunyan and S. G. Ambartsumyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 173-8(1963). (In Russian)

Vvedensky optimum and pessimum phenomena in normal conditions and in various periods, following irradiation with an x ray dose of 700 r, were studied by the electroencephalography method in chronic experiments on eight rabbits with electrodes implanted in the optic cortex. The data showed some phase changes: immediately after irradiation there occurred a shift of optimum towards higher rhythms of irritation, and some time later (24 hours) a considerable shift towards low frequencies took place. In the survived animals the optimum and pessimum frequency levels approached the initial ones. (auth)

**27192** ON CERTAIN MORPHO-HISTOCHEMICAL CHANGES IN THE SPLEEN OF IRRADIATED ANIMALS. Z. E. Ogandzhanyan and Yu. I. Afanas'ev. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 187-95(1963). (In Russian)

Whole-body $\gamma$ irradiation of rats and mice with lethal doses of 900 and 800 r caused significant destructive changes in the spleen. Changes in the lymphoid type cells were manifested within the first 30 min. Hemocytoblasts and reticular cells were relatively resistant to irradiation. The lowering of the nucleic acid level, that of RNA in particular, was observed soon after irradiation. In the hemopoietic elements of the spleen and in immature blood cells, an accumulation of ribonucleins was noted. There was also observed a migration of the cells containing cytochromoxidase towards the foci of the greatest destruction. (auth)

**27193** IMMUNOBIOLOGICAL CHANGES IN IRRADIATED GUINEA PIGS WITH TULAREMIA. S. A. Papoyan, V. N. Zil'fyan, and K. M. Dekhtsunyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 205-15(1963). (In Russian)

Experiments were conducted on guinea pigs immunized with living tularemia vaccine with subsequent 400 r x irradiation. No changes in the course of the vaccine reaction in various groups were noted. Allergic reorientation of the body of irradiated animals was distinctly depressed. Irradiation given one day after immunization sharply decreased antibody formation. At the peak of antibody genesis, irradiation brought about a momentary drop of the agglutinin level. Later on, the level gradually increased. (auth)

**27194** THE ROLE OF THE HYALURONIDASE–HYALURONIC ACID SYSTEM IN RADIATION PATHOLOGY. M. I. Alaverdyan, S. P. Vlasenko, T. Kh. Marukyan, F. O. Airapetyan, and D. G. Grigoryan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 229-34 (1963). (In Russian)

It was found that under the influence of x irradiation a depression of the activity of hyaluronic acid and hyaluronidase takes place. This phenomenon was observed in rats (inhibition of the activity of the testicle's hyaluronidase) and in rabbits (destruction of the hyaluronic acid of the skin), as well as in the test tube. (auth)

**27195** PECULIARITIES AND DIFFERENCES OF GLYCOGEN LOSS BY LEUKOCYTES AFTER X-RAY IRRADIATION OF THE BLOOD IN VITRO AND IN THE BODY. Yu. B. Kheifets and A. L. Shabadash. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 235-40(1963). (In Russian)

Comparison of glycogen changes in neutrophils of the

peripheral blood of a totally irradiated animal with those in the irradiated blood showed that a direct x ray effect on neutrophils is much weaker than that due to the interaction of correlative systems of the whole body. (auth)

**27196** CHANGES IN THE BLOOD LIPID FRACTIONS IN DOGS DUE TO X-RAY IRRADIATION UNDER CONDITIONS OF FAT LOAD. A. G. Shagoyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 245-52(1963). (In Russian)

The absorbability of lipids of different dispersity in dogs x irradiated with subacute doses was investigated. The degree of fat absorbability was determined by means of the blood lipid fractions. (auth)

**27197** ON CERTAIN FUNCTIONAL ALTERATIONS IN THE LIVER IN ACUTE AND SUBACUTE CASES OF RADIATION SICKNESS. M. Kh. Airapetyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 261-8(1963). (In Russian)

Glycogenetic and proteinogenetic functions of the liver, alteration in prothrombin time, and participation of the liver in pigment metabolism were examined during radiation sickness. It was found that in acute and subacute cases of radiation sickness certain disorders of proteinogenetic and glycogenetic functions and of liver metabolism and prothrombin time were observed. Peripheral blood analysis data alone were not sufficient to draw a conclusion about the liver lesions in the case of radiation sickness. In order to determine the degree of the liver lesion it was necessary to examine the blood obtained from the liver vein and the portal vein as well as from the liver itself. (auth)

**27198** INFLUENCE OF ADRENALIN ON BLOOD SUGAR LEVEL OF IRRADIATED AND NON-IRRADIATED ANIMALS UNDER THE EFFECT OF CHLORPROMAZINE. S. A. Akopyan and M. A. Manukyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 269-73 (1963). (In Russian)

Experiments in rabbits showed that the hyperglycemic effect of adrenaline was to some extent more expressed under the action of chlorpromazine (5 mg/kg body weight by intravenous application). The upper limit arrived with delay and the return to the initial level occurred slowly. On the 10th day of irradiation (on the 1st day of clinical evidence of the acute radiation illness), the adrenalinic hyperglycemia intensified, however, in a lesser measure under the effect of chlorpromazine. The weak expression of adrenaline hyperglycemic effect under the chlorpromazine action in conditions of acute radiation illness shows that chlorpromazine blocks brain reticular formation only partially. This conclusion is also maintained by the findings obtained by means of electric irritation of the brain reticular formation. (auth)

**27199** STUDY OF THE INITIAL PHASE OF INTERACTION BETWEEN VACCINE VIRUS AND IRRADIATED CELLS OF TISSUE CULTURE. S. A. Papoyan, R. A. Terpogosyan, L. A. Kamalyan, Zh. Ts. Vartevanyan, A. T. Ter-avetisyan, and M. N. Engoyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 275-81(1963). (In Russian)

A study was made of the initial phase of vaccine development in irradiated and nonirradiated tissue culture. The results obtained showed that preliminary x irradiation (3 C) had no effect on the time of the appearance and degree of virus reproduction in the tissue culture; the infectious virus was detected in the cells 6 to 9 hr after inoculation. Prior to that time the virus presence in the cells was revealed by changes in the luminescence of nucleic acids and in morphological properties. The virus infection caused an earlier and more intense response in nucleic acids of the irradiated cells. (auth)

**27200** THE DIRECT CURRENT INFLUENCE ON ACTIVITY OF BLOOD CATALASE OF IRRADIATED RATS. R. K. Arutyunyan, R. A. Gabrielyan, and S. G. Ambartsumyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 289-91(1963). (In Russian)

Experiments were carried out in 27 white rats to examine the influence of direct current and irradiation (800 r) on activity of blood and brain catalase. It was shown that anodic stimulation of brain during irradiation prevents inactivation of catalase. (auth)

**27201** COMBINED EFFECT OF IONIZING RADIATION AND CHLOROPRENE ON ATP-ASE AND CATHEPTIC ACTIVITY. S. G. Shukuryan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 301-7(1963). (In Russian)

A combined effect of chloroprene and x irradiation on the ATP-ase and cathepsin activity in various tissues of experimental animals is discussed. Experiments showed that chloroprene intoxication depresses the ATP-ase activity in all the tissues investigated. X irradiation brought about different changes in the activity of the enzymes. In the kidneys, the brain, and the myocardium it was decreased, in the liver it remained nearly unchanged, and in the spleen it was considerably increased. Cathepsin activity was markedly higher in the liver, the kidneys, and the brain. Owing to a combined effect of chloroprene intoxication and irradiation, the ATP-ase activity was decreased in all the tissues. It is believed that the changes were of a secondary nature. (auth)

**27202** EFFECT OF IONIZING RADIATION IN BLOOD. E. Scheller. Z. Ges. Inn. Med. Ihre Grenzgebiete, 17: 1129-33(Dec. 15, 1962). (In German)

Ionization of blood components can be produced by x ray, radioisotopes, or cosmic radiation. The dose level of the radiation is very important. Evidence of changes induced by radiation is obtained by staining procedures. These show large cysts that slowly degenerate, found within the red cells. When the residual structures finally disappear from the erythrocyte, it presents the appearance of a red cell ghost. Formation of biologically induced substances in the form of granules or globules a few hours after radiation often can be demonstrated. Similar products can be found in blood from cancer patients, but they are not found in normal blood. Apparently, normal structures are not colored by the staining procedures utilized. In silicosis the tissues affected appear to be much more sensitive to radiation than normal tissue. After radiation, cyst-like particles can be detected in blood that may indicate a primary step in development of lung cancer. One factor that is important to study of abnormal particles found in silicotic blood is that luminescence can be induced in the quartz particles by radiation. This complicates the problem of detecting the cyst-like particles that may be produced. In all cases of silicosis it is necessary to avoid x-ray treatment as much as possible so that additional tissue changes that could induce cancer will not be produced. (BBB)

**27203** COMPARATIVE ULTRAVIOLET AND MAGNETOCHEMICAL EFFECTS ON TRYPSIN. Mary Justa Smith. Thesis, Institutum Divi Thomae, 1963. 221p.

Magnetic fields of 8000 and 15,000 gauss increase the enzyme activity of trypsin. The change in activity was determined by measuring the trypsin-catalyzed hydrolysis of the chromogenic substrate, benzoyl-DL-arginine-p-nitroanilide

at pH 7.8 to 8.5, by measuring adsorption at 410 millimicrons. Simultaneous measurements with a Beckman spectrophotometer DU, using the same samples, showed a lowering of the entire absorption spectra between 220 and 320 millimicrons. It has long been known that ultraviolet light denatures trypsin. This is reflected in a decrease in activity and in elevation of the absorption spectrum. These two methods of measuring changes in the enzymes brought about by the two external agents are opposite, one from the other. This, of course, suggests different mechanisms of action. The determination of the -SH groups produced by ultraviolet radiation and by the magnetic field was sought. A titrimetric procedure for the quantitative estimation of sulfhydryl groups in proteins was used. Complete denaturation by ultraviolet light revealed 3 ± 0.5 -SH/molecule. There were no -SH groups released upon exposure to a magnetic field. Here again the effect is the opposite of that produced by ultraviolet light. A detailed study was made to determine the amount of energy required to inactivate 50% of a given sample of trypsin, in hope that it would be possible to correlate this energy with that responsible for the increased activity after exposure to a magnetic field. It was possible to show that the quantum yield is around 3 to $5 \times 10^{-2}$. An investigation of the infrared spectra of native trypsin, UV irradiated, and trypsin exposed to a magnetic field was undertaken. Each spectrum was dominated by the N-H bands in the 3 micron region. The magnetic field produced a 5% increase in absorption, suggesting an increase in N-H stretching vibration, and a broadening of the band in this region. Ultraviolet light did not appreciably alter the spectrum here; however, it did broaden the band around 9 microns, which would indicate a decrease in coupling; it likewise decreases the absorption due to the influence of hydrogen bridges. Samples of native trypsin, UV irradiated, and trypsin exposed to a magnetic field were also examined by x-ray diffraction. (Dissertation Abstr., 24: No. 11, 1964)

**27204** PROTECTIVE EFFECT OF β-MERCAPTOETHYLAMINE AND MESENTERIC VESSEL CLAMPING ON INTESTINE-IRRADIATED RATS. Kedar Nath Prasad. Thesis, Iowa City, Iowa, Iowa State Univ., 1963. 62p.

β-mercaptoethylamine (MEA) given intraperitoneally fifteen minutes prior to x irradiation or mesenteric vessel clamping during x irradiation of the exteriorized ileum and jejunum in rats reduced mortality, body weight loss in survivors, and histological damage compared to that in irradiated controls. When animals that received 1800 r and MEA were compared on a mortality and histopathological basis with those exposed to 1400 r with no drug treatment, the responses were very similar. Thus with this method for evaluation, MEA reduced the effect of the x-ray exposure dose by about 20%. MEA and mesenteric vessel clamping were not effective with x-ray exposure doses of 2200 r and above and 3000 r and above, respectively. The combination of the two treatments had a substantial additive protective effect. It resulted in 67% survival at the exposure dose of 3500 r where neither treatment by itself was effective, but became completely ineffective at 4500 r and above. The perfusion technique was used for the study of mucosal uptake of iron by the irradiated small intestine. The entire exteriorized jejunum and ileum was exposed to 1400, 1800, or 1800 r preceded by MEA (100 mg/kg). The decreases in mucosal uptake of $^{59}Fe$ were similar in the above categories for the first three days. The mucosal uptake after MEA and 1800 r was much higher at all times after day 3 than in animals given 1400 r, but on a histological basis, the intestines of both irradiated groups were similar throughout a 20 day period after irradiation. Thus there exists a difference between the rate of histological and physiological recovery in the two groups. The sham-irradiated controls with MEA showed 16% mucosal uptake of iron one day after surgery, but returned to the control level 3 days later. The sham-irradiated controls without MEA showed 17% mucosal uptake of iron one day after surgery, but did not return to the control level until 6 days later. Mucosal uptake of $^{59}Fe$ by the small intestine of rats was below normal when MEA (100 mg/kg) was given intraperitoneally 15 minutes before perfusion. The clamping of the mesenteric vessels during the entire period of perfusion reduced the mucosal uptake even more than MEA. Activity of $^{59}Fe$ in the blood of the clamped group was twice the normal value. Consistent blood values were not obtained in the MEA group. The mucosal uptake of $^{59}Fe$ was much higher at pH 4 than at pH 2 and 6, but the blood activity was considerably higher at pH 2 than at pH 4 and 6. (Dissertation Abstr., 24: No. 11, 1964)

**27205** SOME EFFECTS OF X-IRRADIATION ON THE UTILIZATION OF $C^{14}$-LABELLED L-TYROSINE AND MELANIN PRODUCTION IN RANA PIPIENS TADPOLES. Thomas Jacob Craft. Thesis, Columbus, Ohio, Ohio State Univ., 1963. 72p.

Correlations between specific exposures of x irradiation, the uptake of L-tyrosine, and melanin production in selected developmental states of Rana pipiens tadpoles were investigated. Twelve to 14 and 38 to 44 mm tadpoles were exposed to x-ray doses of 250 to 2000 r and 5850 to 23,400 r, respectively. $^{14}C$-labeled L-tyrosine was administered to specimens in the amount of 1.66 mg per gm of body weight for a period of 48 hours before and 48 hours after x irradiation. $^{14}CO_2$ produced by the animals was collected in 2N KOH and measured with a liquid scintillation spectrometer. The amount of $^{14}C$ retained by the animals was calculated. The amount of light that could be reflected from a spot just posterior to the head region on the animals' dorsum was measured with the use of a spot reflection densitometer. This provided an index to the amount of melanin contained by animals. Some $^{14}CO_2$ was produced and some $^{14}C$ was retained before and after x irradiation. $^{14}CO_2$ production and $^{14}C$ retention increased following x irradiation. High $^{14}C$ retention did not, necessarily, indicate increased melanin production. X irradiation doses as low as 250 r cause an immediate increase in light absorption; however, this increase lasts about 24 hours only with x irradiation doses below 1000 r. Animals exposed to 500 to 2000 r plus tyrosine absorbed less light between the second and tenth days following x irradiation than animals receiving x irradiation without the administration of tyrosine. This pattern reverses itself in animals receiving exposures of 5850 to 23,400 r. One thousand roentgens of x irradiation seem to represent the level of energy necessary to dissipate the autoxidation inhibitors in the tissues of 12 to 14 mm tadpoles of Rana pipiens, and additional energy seems to be required to offset increases in redox potential brought about by an increased amount of tyrosine. (Dissertation Abstr., 24: No. 11, 1964)

**27206** GROWTH DYNAMICS OF A RADIATION-INDUCED STRAIN OF HYMENOLEPIS DIMINUTA. Carolyn Patton Hutchins. Thesis, Knoxville, Tenn., Univ. of Tennessee, 1963. 79p.

An attempt was made to determine if successive doses of irradiation on eight consecutive generations of Hymenolepis diminuta would in any way affect the patterns of growth of that organism. Growth in length, increase in the number of proglottids, rate of infectivity, and distribution in the intes-

tine for each day postinfection, before patency, and egg output after patency were used as criteria to determine differences in growth dynamics from the unirradiated controls. There were very few differences between the irradiated strain of H. diminuta and the normal strain. The irradiated strain began producing eggs on the sixteenth day postinfection while the normal strain began producing eggs on the seventeenth day. This resulted in a difference which persisted until peak egg production was reached. In both the normal and irradiated strains those worms reared in male rats rose to peak egg production more gradually than those reared in female rats. Peak egg production was reached by day twenty-two postinfection in all the experimental groups. There were no significant trends of differences between the irradiated and the normal strains or between the worms of the same strain reared in male and female rats, after the onset of peak egg production. This peak was maintained in all groups as late as forty days postinfection when the experiment was terminated. There was a conspicuous decrease in length of the irradiated strain on day fifteen postinfection followed by marked fluctuation. A conspicuous decrease in length was not noted in the normal worms as late as seventeen days after infection. The earlier fluctuation in the lengths of the irradiated worms probably indicates that these worms began shedding gravid proglottids earlier than the normal worms. Proglottisation in the irradiated worms paralleled the morphological development of the normal strain. There were no differences in infection rates or in distribution in the intestine between the normal and irradiated strains, or even between worms of the same strain reared in male and female rats. It was surprising that the progeny of worms that received 15,000 r for eight consecutive generations differed so little from the unirradiated controls. (Dissertation Abstr., 24: No. 11, 1964)

**27207** DEISTVIE IONIZIRUYUSHCHIKH IZLUCHENII NA ZHIVOTNYI ORGANIZM. (Effects of Ionizing Radiation on Animal Organism). A. A. Gorodetskii, ed. Kiev, State Publishing House of Medical Literature, 1960. 482p.

Seventy-six papers presented at the conference of the Ukrainian Society of Roentgenologists and Radiologists and the Institute of Physiology at the Ukrainian Academy of Sciences, Kiev, June 9–13, 1958 are included. The papers consider the general problems of radiation effects on animal organisms, dosimetry and effects of small ionizing doses, metabolism during radiation injuries and sickness, effects of ionizing radiation on morphological and hematological changes, and pathogenesis of radiation sickness. Therapeutic measures, accumulation and excretion of radioactive isotopes from an organism, and the course of infection and immunity are also discussed. (R.V.J.)

## Radiation Effects Therapy and Countermeasures

**27208** (EUR-125.e) RECENT DATA ON THE TREATMENT OF RADIATION INJURIES. A. Massart and J. Rodesch (European Atomic Energy Community). 1963. 29p.

The pharmacological properties of the peripheric vasodilator drug padutin are reviewed. The padutin-depot (callicrein) method was successfully used in the medical treatment of a late-developing radionecrosis for which the only other solution available was amputation. The results obtained from the research carried out pursuant to these findings prompted a review of recent clinical and scientific data concerning this method of treatment. A preliminary survey of the chemical, physiological, and pharmacological properties of padutin is followed by a general outline of radiolesion pathology. Six cases are described in which cures were effected, illustrations of which are given in the text. The radiolesions in question differed in origin, intensity, and age and represented accidental radiodermatitis and radionecroses contracted in industry, research, and radiotherapy. The duration of the treatment depended on whether the lesion became apparent early or late and also on the physical conditions in which irradiation occurred. Normal cicatrization was induced in the extremely stubborn radionecrosis dating back 37 yr for example, after treatment lasting one yr. An early-developing ulcerated radiodermatitis was cured in six weeks. The effect of padutin is also discussed, and the view advanced that the substance possesses trophic properties in addition to its well known function as a peripheric vasodilator. The nutrition of the cells is restored by improving the capillary system, which is impaired by irradiation. The granulations and epithelization are stimulated and healing is rapid and permanent. Mechanical trauma at the point of the original radiolesion does not give rise to any complications. The possibility is considered of achieving similar results by applying the same treatment to radionecroses of the bone. (auth)

**27209** (ORNL-3601(p.116-27)) MAMMALIAN RECOVERY. (Oak Ridge National Lab., Tenn.).

Progress is reported in studies on the recovery of mammals from radiation injuries. Data are included from studies of mortality from secondary disease in homologous bone marrow mouse chimeras; nitrogen balance in normal mice and mouse radiation chimeras; muramidase activity in the kidneys, spleen, and bone marrow of mice carrying rat bone marrow grafts; electron microscopic autoradiographic and histologic studies of mouse spleen after antigenic stimulation; the preservation of mouse bone marrow by storage in liquid nitrogen; the culture of mouse bone marrow cells and leukocytes; the development of a test for parental antigens in hybrid mice, and the effects of treatment with organic phosphates on parasite infestations in mice. (C.H.)

**27210** (ORNL-3601(p.187)) CHEMICAL PROTECTION AND ENZYME CATALYSIS. (Oak Ridge National Lab., Tenn.).

Glutathione (GSH) (1.6 g/kg intraperitoneally) given to $BC3F_1$ mice ($LD_{50/30}$, 720 r) 15 min prior to x radiation yielded an $LD_{50/30}$ of 1050 r, while GSH when given 1 hr before radiation showed no protective effect. With AET (360 mg/kg intraperitoneally) the $LD_{50}$ was 1500 r when the chemical was given 15 min before radiation and 1200 r when given 1 hr before radiation. The mixture of AET (480 mg/kg) and GSH (1.6 g/kg) intraperitoneally, with an initial $LD_{50}$ of 1700 r at 15 min, dropped to 1450 r at 1 hr, 1250 r at 2 hr, and 950 r at 3 hr. Thus, GSH effectively increased the span of action of AET administered intraperitoneally. The mixture also apparently protected the intestinal system better than the hemopoietic, as evidenced by the increased $LD_{50}$ obtained when isologous bone marrow posttreatment was added to the chemical pretreatment. In both $1C3F_1$ and $BC3F_1$ mice, the injection of $50 \times 10^6$ fresh, isologous bone marrow cells one day after pretreatment with the mixture and x radiation raised the $LD_{50}$ to approximately 2100 r, a dose reduction of nearly 3. Investigation of the components of GSH for protective activity has so far shown them to have little activity. On a molar basis, cysteine is about one-half as active as

GSH, 1.6 g/kg intraperitoneally yielding an $LD_{50}$ of 1100 r. Cysteinylglycine and glutamylcysteine were synthesized and, on testing, at equal molar levels, found to have little or no protective effect. Apparently, the intact GSH molecule is necessary for reasonable protective activity. Additional thiophosphate compounds were prepared and tested for protective activity. 2-Aminoethylthiophosphate monosodium salt at 480 mg/kg intraperitoneally gave an $LD_{50/30}$ of 1450 r, as did 1 g/kg of 3-aminopropylthiophosphate monosodium salt and 800 mg/kg of DL-2-aminopropylthiophosphate monosodium salt. These thiophosphate compounds are relatively stable at neutral pH, and it is unlikely that they are materially hydrolyzed to the aminomercaptan in the short time prior to irradiation. (auth)

**27211** (TID-20695) FRACTIONATION OF THE CELLULAR ELEMENTS OF BONE MARROW AND OTHER HEMATOPOIETIC TISSUES IN AN ATTEMPT TO AVOID HOMOLOGOUS DISEASE AND AID THE ACCEPTANCE OF HOMOLOGOUS TISSUE GRAFTS. Progress Report, September 1963–August 1964. Irwin L. Stoloff and Arthur J. Weiss (Jefferson Medical Coll., Philadelphia). Contract AT(30-1)-2862. 8p.

Progress is reported in the separation of mouse bone marrow fractions by density gradient centrifugation. It was demonstrated that cells separated by this method were viable and protected isologous and homologous hosts against lethal radiation injuries. Homologous cells from sucrose fractions offered more protection than an equal number of whole marrow cells. A delayed radiation syndrome was observed in x-irradiated mice given 500,000 isologous marrow cells or two million homologous cells. Two million isologous cells prevented this syndrome. Small numbers of cells were labeled with tritiated thymidine and separated in a sucrose gradient. The labeled cells concentrated near the bottom of the gradient. (C.H.)

**27212** INFLUENCE OF TEMPERATURE AND CYSTEINE ON THE RADIATION EFFECT IN THE CYPRIDINA LUCIFERASE-LUCIFERIN SYSTEM IRRADIATED WITH ROENTGEN RAYS. W. Lohmann, C. F. Fowler, and W. H. Perkins (Univ. of Arkansas, Little Rock and Veterans Administration Hospital, Little Rock, Ark.). Acta Radiol., 2: 17-23(Feb. 1964).

Luciferase and luciferin solutions were x irradiated at different temperatures. At 28°C cysteine protected both substances when present in solution before the irradiation. When frozen luciferase was irradiated at –20°C, the maximal radiation effect did not develop until the melted sample had been at room temperature for about 25 min. Storage at –20°C for up to 90 hr after irradiation did not modify the latent radiation effect. Cysteine exhibited a protection after irradiation if added to frozen luciferase prior to thawing. (auth)

**27213** ON CHEMICAL AND BIOLOGICAL PROTECTION AGAINST RADIATION INJURY. III. EFFECTS OF ADMINISTRATION OF LYSOZYME ON ACUTE AND CHRONIC RADIATION INJURY. Vito Diomede-Fresa and Donato Fumarola (Università, Bari, Italy). Ann. Med. Navale, 66: 777-84(Nov.-Dec. 1961). (In Italian)

A partial radioprotective action of lysozyme was demonstrated in both acutely and chronically irradiated rabbits. In acute experiments, 2500-g rabbits received a single whole-body dose of 2000 r of 180-kv x rays and were injected intravenously, beginning four days before irradiation, with 2-mg/kg (body wt) doses of lysozyme daily. These animals died, on the average, 167 hr postirradiation, the last one surviving until the 192nd hr; whereas in the irradiated controls the average survival time was 3.5 hr and the last animal died the fifth hour postirradiation. In the chronic irradiation experiments, 100-r doses were given daily until death along with daily intravenous injections of 2 mg/kg of lysozyme. The average and maximum survival times of these injected animals were 32 and 36 days, compared with 20 and 24 days in irradiated, uninjected control rabbits. The results indicate that lysozyme, as previously found with properdin, acting as nonspecific antibacterial agent, prolongs the course of radiation sickness, presumably by favorably affecting the bacteremic phase. (BBB)

**27214** RADIOPROTECTIVE EFFECTS OF ETHYL PALMITATE AND OF PLANT OILS IN ANIMAL EXPERIMENTS. Kurt Flemming (Universität, Freiburg i. B. and Heiligenberg-Instituts, Ger.). Biophysik, 1: 339-42(1964). (In German)

Protective effects of ethyl palmitate and various plant oils against radiation injuries were investigated. Mice were injected with 100 mg ethyl palmitate and 48 hours later were irradiated with 690-r x rays. After 30 days the survival rate was measured. Results proved that the ethyl palmitate exerted protective effects against radiation damage. Since palmitic acid is an important constituent of olive oil and other vegetable oils, studies were made of the radioprotective effects of olive oil, peanut oil, linseed oil, and sunflower oil. Each of these showed protective effects. (M.C.G.)

**27215** THE UV-RADIATION-SENSITIZED EFFECT OF 5-HALOURACIL. H. Dellweg, D. Jacherts, D. Weinblum, and A. Wacker (Universität, Frankfurt am Main). Biophysik, 1: 391-5(1964). (In German)

It was found previously that cells in which a part of the thymine is replaced by 5-halouracil have a higher sensitivity to uv radiation. Enterococcus was cultivated in the presence of 5-halouracil (2-$^{14}$C). DNA was isolated from this bacteria and irradiated. It was established that the halouracil in the DNA was changed under the influence of uv radiation by dehalogenation to uracil. In addition, there were smaller amounts of other photoproducts, such as uracil dimers and mixed dimers of uracil and thymine. A comparison of the curve for survival rate of the bacteria after irradiation with these results showed an uv-sensitizing effect in the order chlorouracil < iodouracil < bromouracil, the same as the order in the dehalogenation reactions. Radiosensitizing effects of 5-bromouracil were observed with E. coli. (M.C.G.)

**27216** RADIATION EFFECTS AND RADIATION PROTECTION IN THE CASE OF X-RAY IRRADIATION OF NUCLEIC ACID BASES. E.-R. Lochmann, D. Weinblum, and A. Wacker (Universität, Berlin and Universität, Frankfurt am Main). Biophysik, 1: 396-402(1964). (In German)

The effects of x radiation on nucleic acid bases were investigated. By use of radioactive bases the distribution of radioactive transformation products after irradiation was determined by paper chromatography. The pH dependence of radiation effects on uracil, thymine, cytosine, adenine, bromouracil, and guanine was determined. The protective effects of various amino acids against radiation damage to DNA and its bases were studied. The simple amino acids had no protective effect. The OH-containing amino acids had a slight effect, which was intensified in the case of branched amino acids. (M.C.G.)

**27217** PROTECTIVE EFFECTS OF CYSTEINE AND AET IN THE CASE OF RADIOINDUCED DOMINANT LETHAL MUTATIONS OF MICE. U. Ehling (Institut für Strahlenschutzforschung, Neuherberg, Ger.). Biophysik, 1: 427-8(1964). (In German)

Protective effects of cysteine and AET against radioinduced mutations were studied. Male mice were injected with NaCl, cysteine, or AET and irradiation with x rays to 600 and 900 r. The effects of the pretreatment on the length of the sterile phase were determined. The sterile phase after 600 r lasted 57 days (100%) for pretreatment with NaCl. Pretreatment with cysteine shortened the sterile phase about 17% and AET about 30%. At 900 r mortality amounted to 100% after NaCl pretreatment, 16% after cysteine, and 1% after AET. The greatest protective effect was shown if pretreatment was 15 to 20 min before irradiation. (M.C.G.)

**27218** INTERMOLECULAR INTERACTIONS BETWEEN GLYCEROL AND CATALASE. INFLUENCE ON THE RADIOSENSITIVITY OF THE ENZYME. W. Lohmann, A. J. Moss, W. H. Perkins, and Ch. F. Fowler (Univ. of Arkansas, Little Rock and Veterans Administration Hospital, Little Rock). Biophysik, 2: 16-21(1964). (In German)

The x-ray inactivation of catalase in the presence of glycerol was investigated. Even small amounts of glycerol (0.0004 vol %) gave an excellent and maximum protective effect. From the results it was concluded that complex formation between glycerol and iron centers in the enzyme molecule produces the protective effect. (auth)

**27219** EFFECT OF CARBOHYDRATE ON THE BLOOD UREA LEVEL IN X-IRRADIATED NEPHRECTOMIZED RATS. N. Sestan and V. Stankovic (Inst. "Ruder Boskovic," Zagreb). Bull. Sci., Conseil Acad. RPF Yougoslavie, 8: 134-5(Oct.-Dec. 1963).

The blood urea concentration in nephrectomized and previously irradiated male rats (600 r) was higher than in the nephrectomized unirradiated controls; it amounted to 91.7 ± 2.5 mg/100 ml in the irradiated animals compared to 64.3 ± 1.6 mg/100 ml in the controls. The rise in blood urea was less pronounced if, immediately after nephrectomy, the rats were intravenously injected with 1 ml of 20% fructose or glucose solution per 100 g body weight. Some possible explanations of this effect are discussed. (auth)

**27220** EXPERIMENTAL INVESTIGATIONS ON RADIOPROTECTIVE EFFECTS IN GUINEA PIGS. 5-HYDROXYINDOLYL-3-ACETIC ACID. H. Hobi (Dermatologische Universitätsklinik, Basel). Dermatologica, 127: 435-44(1963). (In German)

The radioprotective action of 5-hydroxyindolyl-3-acetic acid was examined in relation to the activity of serotonin (5-hydroxytryptamine) as a radiation protector and with regard to its toxicity. Depilation was used as a measure of the radiation effect. The left side of the animal was x irradiated (55 kv, 10 ma, 2 cm dia) after shaving and treatment with Depilatorium 524 Ciba. After 24 hr the material to be tested was injected and the right side immediately irradiated. At 800 r hair began to fall out between the eighth and fourteenth day; at 1200 r depilation of unprotected areas was irreversible. As controls, several animals were injected (two for each test) with 50 mg/kg, 35 mg/kg, and 20 mg/kg serotonin intraperitoneally, later 1200-r irradiation producing depilation to the extent of 12, 25, and 75%, respectively. A protective index was defined as the number of non-depilated areas divided by the number depilated in a number of tests. At doses of 50 mg/kg, the following compounds had the reported indexes at 1200 r: DL-5-hydroxytryptophane, 0.6; 5-hydroxy-4(2'-aminoethyl) indole oxalate, 0.1; 5,6-dimethoxytryptamine, 0.3; 5-hydroxyindolyl-3-acetic acid, 0.7. This last material was examined at 50 mg/kg, 25 mg/kg, and 10 mg/kg, irradiation producing depilation of 10, 50, and 90%. This remarkable activity is only prophylactic, having effect only when the substance is applied at least five min before irradiation; irradiation 10 min later shows no protective action. (BBB)

**27221** PROTECTIVE EFFECTS OF ACRIDINE ORANGE AGAINST ULTRA VIOLET IRRADIATION OF INFECTIOUS DNA OF THE $1_\varphi$-7 PHAGE. G. V. Zavil'gel'skii, B. N. Il'yashenko, E. E. Minyat, and O. N. Rudchenko (Inst. of Radiation and Physico-Chemical Biology, Academy of Sciences, USSR and Gamalen Inst. of Epideniology and Microbiology, Academy of Medicine, USSR). Dokl. Akad. Nauk SSSR, 155: 937-9(Apr. 1, 1964). (In Russian)

Spectral variations appearing in acridine orange (AO) complexing with DNA indicate a strong reaction. An attempt was made to use acridine orange as a protective substance against ultraviolet inactivation of $1_\varphi$-7 phage DNA. Considering a possible energy migration from the DNA to the AO, it is possible to anticipate an AO protective absorption by de-excitation as fluorescence or as internal conversion into heat. The survival of $1_\varphi$-7 phage was plotted as a function of uv dose. The protective efficiency of AO is expressed in the series 1 : 0.64 : 0.37 : 0.21. Treatment with AO reduced the quantum yield from lethal uv effects by a factor of 1.6 when used in $5 \times 10^{-7}$ M; 2.85, in $5 \times 10^{-6}$ M; and 4.8, in $5 \times 10^{-5}$ M concentrations. In contrast to the infectious DNA, the treatment of bacteriophage as a whole with AO exhibits no protective effects. The inactivation curve for the control phage coincides with the AO treated phage for $5 \times 10^{-6}$ M concentration, indicating the AO is not effective (DNA-albumin shell) because of low penetrability. (R.V.J.)

**27222** A FACTOR ('RLP') FROM SHEEP SPLEEN WHICH INHIBITS RADIATION LEUKAEMOGENESIS IN MICE. I. Berenblum, G. Cividalli, M. E. Hodes, and N. Trainin (Weizmann Inst. of Science, Rehovoth, Israel). Nature, 202: 973-4(June 6, 1964).

Evidence is presented that a number of fractions from sheep spleens have a protective effect against radioinduced leukemogenesis in mice. Best results were obtained with crude homogenate but supernatant and precipitate fractions, separated by centrifugation, also showed a protective effect. The mice tolerated repeated intraperitoneal injections of the crude homogenates of sheep spleen well. It is concluded that a cell-free factor, called radiation-leukemia-protection (RLP) factor is present in sheep spleen. (C.H.)

**27223** EFFECT OF AN ANTIBIOTIC REGIME ON MONKEYS EXPOSED TO TOTAL-BODY IRRADIATION. J. W. Byron, Mary V. Haigh, and L. G. Lajtha (Christie Hospital and Holt Radium Instr., Manchester, Eng.). Nature, 202: 977-9(June 6, 1964).

Monkeys (Macaca mulatta) were exposed to 820 rads whole-body x radiation. Survival rates were compared for those treated with tetracycline before and after exposure, those given antibiotics plus typhoid-paratyphoid vaccine (TAB), and untreated animals. The animals treated with antibiotics were free of anorexia and almost free of diarrhea while those treated with TAB showed an early recovery in blood neutrophil levels. No significant differences in survival rate were observed in the three groups of monkeys. (C.H.)

**27224** ON THE INFLUENCE OF 5-HYDROXYTRYPTAMINE ON THE RADIOINDUCED CHANGES IN THE NEUROSECRETORICAL MIDBRAIN SYSTEM OF THE RAT. Ulrich Heckmann, Hans A. Kuenkel, and Erika Lappe (Universität, Hamburg). Naturwissenschaften, 51: 219(1964). (In German)

Radioprotective effects of 5-hydroxytryptamine (Serotonin) on neurosecretion in the hypophysis posterior lobe in irradiated rats were investigated. (M.C.G.)

**27225** EFFECT OF HEMOSTIMULANTS AND AGENTS WHICH CHANGE THE REACTIVITY OF THE ORGANISM ON HEMOPOIESIS IN IRRADIATED ANIMALS. E. A. Dikovenko. Nektorye Vopr. Sovrem. Med., Sb., 29-30(1963).

An investigation was carried out on 1,170 rats, 272 guinea pigs, and 106 rabbits concerning the effect on the blood-formation system of combinations of pentoxyl (I); (40 to 60 mg/kg) with ACTH (0.5 to 2.5 units/kg), cortisone (2.5 mg/kg), dibazole (5 mg/kg), and phenamine (0.5 to 1 mg/kg). Furthermore, the therapeutic effect of intermediate products of the biosynthesis of nucleic acids (NA) was investigated. The animals were subjected to $\gamma$ irradiation from $^{60}Co$ with $DL_{40/50}$. The evaluation of the action of the substances investigated was carried out on the basis of studies of the blood, the weight of the spleen, the level of inclusion of $^{32}P$ into NA, and the general course of radiation sickness, the dynamics of weight changes, and the rate of survival of the animals. Cortisone and ACTH did not increase the therapeutic effect of (I). In guinea pigs ACTH produced an increase in hemorrhagic diathesis and in mortality. Dibazole in rabbits and rats during the first days after irradiation increased the effect produced by (I), but was ineffective in later periods. Phenamine increased the effect of (I). A positive effect of orotic acid and ATP was observed. Leucocytin produced a weak effect that was lower than that of (I) or metacyl. Uracil presented no advantages as compared with (I). RNA and muscle adenylic acid as well as their combinations with (I) did not produce a therapeutic effect. Combination of (I) with ATP exerted a beneficial effect on the course of radiation sickness. Pyrimidine bases and orotic acid play an important role in the normalization of the NA synthesis in the organism after irradiation. The presence of an adequate amount of ATP is also necessary. The action of these substances cannot be ascribed to replacement of missing components of metabolism; it is more complex. (Referativnyy Zhurnal Biologiya, No. 17, Sept. 1963)

**27226** EXPERIMENTAL STUDIES ON THE RADIOPROTECTIVE EFFECTS OF OLIVE OIL ON MICE. A. Giordano and R. Cantù (Università, Pavia). Radiobiol. Radioterap. Fis. Med., 18: 475-86(Nov.-Dec. 1963). (In Italian)

A daily dose (0.8 g) of olive oil was administered for a week to a group of 40 mice. Qualitative and quantitative composition of the olive oil was previously ascertained. On the eighth day these mice and 20 other controls received a total-body irradiation, in a single exposure, of 600 r. The effects on survival rate, values of erythrocytes and leukocytes, bone marrow, and oleate and stearate concentrations in serum showed that olive oil has protective and therapeutic effects on whole-body x-irradiated mice. (auth)

**27227** THE INFLUENCE OF CYSTEAMINE AND AET ON THE OXIDATIVE PHOSPHORYLATION OF IRRADIATED LYMPHOSARCOMAS OF ASCITES TYPE. H.-J. Altenbrunn (Robert-Rössle-Klinik, Berlin). Radiobiol. Radiotherap., 5: 71-5(1964). (In German)

Mitochondria of tumors were shown to be functionally like the mitochondria of radiosensitive organs. Cold storage caused the oxidative phosphorylation quotient to decrease rapidly. Coenzymes were needed for optimal oxidative phosphorylation in mitochondria of both tumors and radiosensitive organs. Metabolic activity and oxidative phosphorylation were decreased after irradiation in tumor cells and radiosensitive organs. These decreases in metabolic activity were prevented both in vivo and in vitro by the application of cysteamine or AET before irradiation. (C.H.)

**27228** ABOUT THE RADIOPROTECTIVE SUBSTANCES AND THE RADIATION PROTECTION. Z. Zseboek (University Clinic, Budapest). Radiobiol. Radiotherap., 5: 97-112(1964). (In German)

The development of the chemical radiation protective compounds is reviewed. The necessary separation into chemoprophylaxis and chemotherapy is pointed out. The theoretical principles and existing results are discussed. Emphasis is placed on the effects of substances of the cysteamine group. Experimental results are reported that agree with the values reported from literature. It is stated that under defined conditions more successful protectives may be available. (auth)

**27229** INVESTIGATIONS OF RADIOSENSITIVITY OF CATALASE. E. Magdon (Robert-Rössle-Klinik, Berlin). Radiobiol. Radiotherap., 5: 233-41(1964). (In German)

The radiosensitivity of catalase was found to depend on the O content of the irradiated solution of enzyme and on the dose rate of the radiation used. This different radiosensitivity is caused by hydrogen peroxide formed in a different amount in dependence on O content and dose rate. The protective effect of hydrogen peroxide on the radioinduced catalase inactivation is given by the formation of reversible catalase–hydrogen peroxide complexes. The catalase is supposed to influence the biological effect of ionizing radiation by destroying $OH^{\cdot}$ and $HO_2$ radicals in terms of the catalase–hydrogen peroxide complex. (auth)

**27230** INVESTIGATIONS OF THE EFFECT OF GIBBERELLIC ACID ON CATALASE ACTIVITY AND RADIOSENSITIVITY OF BIOLOGICAL SYSTEMS. E. Magdon (Robert-Rössle-Klinik, Berlin). Radiobiol. Radiotherap., 5: 243-7(1964). (In German)

It was shown that gibberellic acid increased the catalase activity as well as decreased the radiosensitivity of bacteria depending on the concentration and duration of action. The prophylactic radioprotective effect given by treatment before irradiation was clearly marked in the concentration range 1 to 7.5 mg % gibberellinc acid. The bacteria treated after irradiation showed a significant decrease of radiation effect only in the concentration range 5 to 7.5 mg % gibberellic acid. The radioprotective effect of gibberellic acid which was found to be based on the increased catalase activity. This suggests further investigations of other biological materials to develop radioprotective substances by influencing the catalase activity. (auth)

**27231** INVESTIGATIONS OF CATALASE ACTIVITY AND RADIOSENSITIVITY OF TUMOUR CELLS. E. Magdon (Robert-Rössle-Klinik, Berlin). Radiobiol. Radiotherap., 5: 249-52(1964). (In German)

It was found that tumor cells having a different catalase activity possessed in vivo a different radiosensitivity. The radiosensitivity of tumor cells was determined to be inversely proportional to their catalase activity. An increase of catalase activity involved a decrease of radiosensitivity. (auth)

**27232** THE PART OF CATALASE ACTIVITY OF LIVER, SPLEEN AND BLOOD IN THE BIOLOGICAL RADIATION INJURY. E. Magdon (Robert-Rössle-Klinik, Berlin). Radiobiol. Radiotherap., 5: 253-8(1964). (In German)

It was found that catalase activity of blood was a factor of race-, strain-, and sex-conditioned radiobiological sensitivity in different higher animals and in different genetically uniform strains of mice. Moreover, the catalase activity of spleen and liver was of special importance in the radiobiological sensitivity. The different radiosensitivity of liver and spleen is due to a different specific catalase activity of the two organs. (auth)

**27233** INVESTIGATIONS ON A BIOLOGICAL RADIATION PROTECTION. PART 51. THE INFLUENCE OF SPLENECTOMY ON RADIATION-CAUSED CHANGES IN AMINO ACID METABOLISM IN MICE. Hans-Joachim Melching, Christian Streffer, and Horst Sauer (Universität, Freiburg i. B.). Strahlentherapie, 123: 571-99(Apr. 1964). (In German)

The influence of prophylactical splenectomy, done 14 days prior to sublethal total body irradiation of mice, on radioinduced changes of cysteine and tryptophane metabolism was investigated. There were obvious similarities to the effectiveness of radiation protective substances; on the other hand there was a distinct difference in the influence upon the excretion of xanthuric acid. After administration of radioprotective substances, such as 5-hydroxytryptamine, or pyridoxal-5-phosphate + 5-adenosinemonophosphate, antagonism could be observed between the effectiveness of splenectomy and the administration of 5-hydroxytryptamine. (auth)

**27234** INVESTIGATIONS ON AN INFLUENCING OF BIOLOGICAL X-RAY EFFECTS BY KALLIKREIN INACTIVATOR AND KALLIKREIN. Wolfgang Pabst (Max-Planck-Institut für Biophysik, Frankfurt am Main and Max-Planck-Institut für Ernahrungsphysiologie, Dortmund, Ger.). Strahlentherapie, 123: 600-8(Apr. 1964). (In German)

The influence of kallikrein-inactivator and kallikrein on the life-span-reducing effect of x rays (180 kv) on mice (radiation doses from 550 to 20,000 r) was investigated. Neither of the substances, administered in physiological doses after a single short irradiation caused significant change in the survival time of treated animals compared to the control animals, which were irradiated only. There was reduced tolerance to kallikrein after repeated irradiation. It was concluded that kallikrein is of no importance in the development of radiation damage in the organism. Neither the hormone nor its inactivator had therapeutic effects against the biological effects of ionizing radiation. (auth)

**27235** ON TREATMENT OF RADIATION SICKNESS COMPLICATED BY ACUTE BLOOD LOSS. M. A. Movsesyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 27-36(1963). (In Russian)

The complexity and variety of pathogenic mechanisms of acute radiation sickness, complicated by blood loss, require complex therapy. On the basis of experiments carried out on dogs and rabbits a scheme of treatment is suggested. (auth)

**27236** EFFICIENCY OF LOBELINE INJECTED BY DIFFERENT METHODS INTO IRRADIATED ANIMALS. S. A. Akopyan and S. S. Grigoryan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 111-20(1963). (In Russian)

Experiments were carried out on irradiated (800 to 1000 r) animals. The result obtained is as follows: lobeline brings about a stimulating effect on the respiratory center of normal animals both in intravenous and intramuscular injections. In intravenous injection a required threshold dose of lobeline is considerably smaller. The effect of intravenously injected lobeline on the respiratory center is accomplished predominantly by means of reflexes while that of lobeline injected subcutaneously is brought about humorally. In the case of acute radiation sickness the excitability of the reflex arc decreases, making lobeline injected intravenously lose its efficiency. Under this condition the effect of lobeline injected subcutaneously is not observed either. To stimulate the respiratory center in animals suffering from acute radiation sickness, lobeline should be injected intravenously. (auth)

**27237** EFFECT OF CORTISONE AND ADRENOCORTICOTROPIC HORMONE ON OXYGEN CONSUMPTION BY IRRADIATED RATS. S. P. Vlasenko and D. Kh. Garibyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 145-50(1963). (In Russian)

Experimental data showed that certain hormones of hypophysisadrenal glands produce a considerable effect on gas exchange in animals subjected to ionizing radiation. It was observed that under the effect of cortisone irradiated rats consumed much less oxygen. Adrenocorticotropic hormone (ACTH) injections gave rise to a gas exchange stimulation which, however, was not evident at the terminal stage of radiation sickness. Daily ACTH and cortisone injections, one day after irradiation, greatly aggravated the course of radiation sickness and shortened the lifetime of experimental animals. (auth)

**27238** INFLUENCE OF DIRECT CURRENT ON SURVIVAL OF IRRADIATED ALBINO RATS. R. K. Arutyunyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 241-4(1963). (In Russian)

The survival of 140 white rats after a single x irradiation (800 r) was examined. Brain stimulation with anode current before irradiation and with cathode current after irradiation was found to contribute favorably to the survival of irradiated rats. Successive application of the two electric currents proved to be more effective. (auth)

**27239** ON THE PART PLAYED BY THE ADRENAL CORTEX IN CERTAIN CASES OF RADIATION LESION. S. P. Vlasenko and D. Kh. Garibyan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 253-9(1963). (In Russian)

It was shown that a total adrenalectomy considerably aggravated the course and outcome of radiation lesions. In the case of a partial adrenalectomy the lifetime of irradiated rats was shortened to a lesser extent. Irradiation of rats with a minimum absolutely lethal dose results in the weakening of the function of the adrenal cortex. This was indirectly proved by diuresis disorders revealed by the Gaunt water test. In the case of bilateral adrenalectomy the consumption of oxygen by rats was greatly reduced. (auth)

## Radiation Hazards and Protection

**27240** DOSE CONCEPT AND DOSE UNITS. R. Glocker (Max Planck-Institut für Metallforschung, Stuttgart). Biophysik, 2: 1-10(1964). (In German)

A definition of radiation dose is presented that includes both the case of point dose and that of average dose. Methods of measuring dose are described. The transferableness of ionization measurements in air to another material in which dose must be determined is discussed. Units for expressing radiation dose are explained. (M.C.G.)

**27241** PROTECTION AGAINST NUCLEAR RADIATION. A. B. Gupta. Bombay Technologists, 14: 7-9(Mar. 1964).

Improving textiles for increasing their protection against thermal radiation in the presence of ionizing radiation is discussed. Radiation effects on cotton, wool, nylon, orlon, and rayons are described. Some processes for making the fibers resistant to radiation effects are discussed. (M.C.G.)

**27242** PROTECTION OF THE PERSONNEL WORKING IN ADJOINING BUILDINGS AND OF THE POPULATION AGAINST γ RADIATION EMITTED FROM THERAPEUTIC INSTALLATIONS. N. I. Zol'nikova, V. Ya. Golikov, A. N.

Krongauz, and I. A. Pereslegin (Sechenov Inst. of Medicine and Research Inst. in Roentgenology and Radiology, Ministry of Health, USSR). Gigiena i Sanit., No. 3, 66-9(Mar. 1964). (In Russian)

It was observed that the 50-cm concrete shielding of the GUT-Co-400 facility may not be sufficient to protect the personnel. The $\gamma$ field 5 m from the walls of the exposure chamber depends on the height of the windows and the thickness of the walls. With windows not larger than one $m^2$, 2 m from the floor, the outside and inside walls should be not less than one meter thick. (R.V.J.)

## Radiotherapy and Radiodiagnosis

**27243** TREATMENT OF PAPILLOMATOSIS OF THE BLADDER WITH RADIOACTIVE ARSENIC $^{76}As$. Jerzy Einhorn, Sven Hultberg, and Arne E. Nilson (Karolinska Sjukhuset, Stockholm). Acta Radiol., 2: 1-16(Feb. 1964).

Intravesical radiotherapy was applied to 25 patients with papillomatosis of the bladder, in 11 of these with $^{76}As$, a new method. The results of the treatment and the complications after long observation periods are described. (auth)

**27244** SHORT-TERM KINETIC STUDIES OF $^{85}Sr$ AND $^{47}Ca$ BY WHOLE BODY COUNTING IN MALIGNANT DISEASES OF THE SKELETON. Ebbe Cederquist (Univ. of Lund, Sweden). Acta Radiol., 2: 42-50(Feb. 1964).

Sixteen patients with malignant diseases of the skeleton were studied for osseous changes using the intravenous injection of nanocurie activities of $^{85}Sr$ and $^{47}Ca$ and a whole-body scintillation spectrometer and scanning geometry in the prone and supine positions. Differences between the two positions in the redistribution and rate of redistribution of isotopes in bone were found in patients with generalized skeletal disease as compared with those without demonstrable skeletal changes. This observation may be of differential diagnostic value and possibly in the evaluation of the effect of different types of therapy. (auth)

**27245** A MULTISOURCE GAMMA RADIATION HEAD FOR LABORATORY WORK. R. Thoraeus (Karolinska Sjukhuset, Stockholm). Acta Radiol., 2: 73-80(Feb. 1964).

The design and features of a multisource head for radioactive sources are described. The head is provided with a movable drawer mechanically operated from the control room, the movement of the drawer acting as a shutter; a 90-C $^{60}Co$ source and a 60-C $^{137}Cs$ source were installed in the drawer. (auth)

**27246** THE CALCULATION OF DOSE DISTRIBUTIONS FOR RECTANGULAR X- AND GAMMA-RAY FIELDS. Mavis L. Emmett (British Royal Hospital, Bristol, Eng.). Brit. J. Radiol., 37: 444-57(June 1964).

A method of calculating isodose curves for rectangular fields which is applicable to x rays of HVT 1, 1.5, 2, 2.5, 3, and 4 mm of Cu, $^{137}Cs$ and $^{60}Co$ radiation, is described. The method is based on the finding that, for these qualities, all the area scatter data can be fitted to the same curve if suitable scaling factors are applied both to the area and the scatter dose. For a particular quality and depth the axial scatter dose was evaluated graphically for various rectangular fields. From these data a chart was drawn showing lines of equal axial scatter dose in terms of the length of the sides of the field. The central axis scatter doses for other conditions may be obtained by shifting a transparent copy of this chart in relation to the axes and dividing the new values read from the shifted chart by a factor (the shift and the factor being dependent only on the new quality and depth). Scatter doses at non-axial points may also easily be obtained from the shifted chart. The total doses and hence the percentage depth doses may be found. A method of correction for the effect of change in source distance and filter obliquity for points off the central axis is given. The adjustment to the isodose curves in the penumbral region to allow for finite source size is also demonstrated. All the tables and charts required for the calculation of isodose curves have been calculated and are shown. The tables and charts are based on the axial percentage depth dose data and surface back-scatter factors given in Supplement 10, The British Journal of Radiology. The method was checked against the original tables. For the x-ray qualities errors rarely exceeded 3 per cent of the local dose on all except the largest field. For $^{137}Cs$ radiation errors rarely exceeded 2 per cent and for $^{60}Co$ radiation errors never exceeded 1 per cent of the local dose. In addition it is shown that the method may be easily and quickly adapted to produce isodose curves at any FSD. (auth)

**27247** A METHOD FOR DETERMINING DOSE-MODIFICATION FACTORS. M. C. Pike (MRC Statistical Research Unit, London) and Tikvah Alper. Brit. J. Radiol., 37: 458-62(June 1964).

When a modifying agent is used in radiobiological studies its effectiveness can be expressed by a single number only when it is dose-modifying, in which case the extrapolation number is the same for survival curves in the presence and the absence of the agent. A method is described for deriving the best fit to two sets of observations when they are treated as if there were a common extrapolation number. The two straight lines are then described by three parameters, instead of the four which would be found by fitting the best line to each set of observations independently. A test must be carried out to see whether the fourth parameter adds significantly to the goodness of fit; if the three parameters are sufficient, there is a considerable gain in the precision with which both the extrapolation number and the dose-modification factor may be determined. A program was written for the Ferranti Mercury computer, to calculate the constants both for the four-parameter and the three-parameter models; the F-ratio used to test the adequacy of the three parameters; and confidence limits on slopes, extrapolation numbers, and dose-modification factors. (auth)

**27248** HISTOLOGICAL FINDINGS IN RETINOBLASTOMAS TREATED WITH RADIATION. F. Kloucek (Charles Univ., Prague). Cesk. Ofthalmol., 18: 411-18(Nov. 1962). (In Czech.)

Histopathologic studies are reported on five patients with bilateral retinoblastomas treated with repeated 100- to 300-r doses of 190-kv x rays. One eye was removed immediately after the diagnosis was arrived at and its fellow was treated by radiation. It too had to be removed after a certain time interval because of failure of radiotherapy. These 5 eyes, treated with radiation, were histologically examined for the degree of destruction of the individual tumors and for the postirradiation changes both in the tumors and surrounding intraocular tissues. The causes are discussed for failure of the radiation treatment in these patients, with reference to the radiation dose, the method of treatment, the size of the irradiated tumor focus, and its histologic grading. The possible future developments of radiotherapy are considered as well as advisability of the use of $\alpha$- and $\beta$-radiation treatments in view of the different biological effects of the radiation and the possible safeguarding of the surrounding normal intraocular tissue from radiation injury. (BBB)

**27249** ON THE RADIOLOGICAL PROBLEMS IN KIDNEY TRANSPLANTATION. I. Lélek and A. Németh (Univ. of Szeged). Fortschr. Gebiete Roentgenstrahlen Nuklearmed., 100: 600-7(May 1964). (In German)

The radiological problems associated with renal transplants are reviewed. In the radiological investigation of the donor, angiography and pyelography are indicated in order to determine whether the donor kidney possesses vessels suitable for grafting. In one case a donor was found with a variation of the renal vessels, which made the kidney unsuitable for grafting. Methods of total-body irradiation are described and reviewed. The effects of this procedure on the rejection of the kidney and the probable temporary reduction in antibody formation, as well as on other effects such as interstitial cellular invasion resulting in rejection of a homotransplant are discussed. The method of irradiation employed resulted in a 79-day survival of the kidney but with only temporary tolerance. (auth)

**27250** THE EVOLUTION OF RADIATION DOSIMETRY. Charles D. Ogilvie. J. Am. Osteopath. Assoc., 61: 444-9(Feb. 1962).

The development of principles and practices in the measurement of radiation dosage, as applied to treatment of human diseases, is reviewed. In early roentgenology no attempt was made to separate the character (quality) from the intensity (quantity) of x rays. Now dose means (or should mean in therapeutic radiology) energy transferred in tissue (absorbed dose). This survey is concerned with dosage chiefly as a measure of intensity, or quantity, of radiation for therapeutic purposes, although the interrelation of quality also is considered. Dosimetry as related to either diagnostic roentgenology or nuclear medicine, is not considered. The development of Ra dosimetry is also discussed as an example of the cooperation between physicist and physician in establishing accurate measurement of doses used in radiotherapy. (BBB)

**27251** THE USE OF SINGLE-CHANNEL SCINTILLATION GAMMA SPECTROMETER IN RADIOISOTOPE DIAGNOSTICS. Vaclav Husak (Faculty Hospital, Olomouc, Czechoslovakia). Jaderna Energie, 10: 113-20(Apr. 1964). (In Czech)

Uses of the scintillation spectrometer were evaluated on the basis of practical experience and literature data. It is convenient for measuring very low activities in vivo because it requires a very short time for measurements. The differential measurement method may be conveniently applied for the detection of radioisotopes in vivo, using directional detectors, and in local diagnostics it sharpens the contrast of the gammagraphic record. A scintillation spectrometer is considered a practical instrument for complex diagnostic methods in which several isotopes are applied simultaneously. (auth)

**27252** THYROID SCINTILLATION SCANNING. METHODOLOGY AND INTERPRETATION. Millard N. Croll and Luther W. Brady (Hahnemann Medical Coll., Philadelphia). N. Y. State J. Med., 63: 211-17(Jan. 15, 1963).

Applications of $^{131}I$ scintillation scanning techniques to obtain anatomic information concerning the thyroid gland are discussed. It is pointed out that these morphological data supplement measurements of thyroid uptake of I and other clinical studies in providing information on thyroid function. Scanning techniques that are of most value in the diagnosis of thyroid disease are stressed. These include demonstration of irregularities in the size and position of the gland, estimates of the clinical potentialities of thyroid nodules, and the demonstration of metastases from primary thyroid carcinoma. It is pointed out that the final interpretation of the scan is dependent on the total clinical and laboratory findings as well as the experience of the interpreter. (C.H.)

**27253** ANODIZED ALUMINIUM GRAINS LABELLED WITH RADIOPHOSPHORUS FOR MEDICAL PURPOSES. F. Badellino (Istituto di Oncologia, Turin), L. Caldarola, G. B. Fasolo, R. Malvano, U. Rosa, and E. Zimmer. Nature, 202: 983-4(June 6, 1964).

Procedures are presented for the preparation of anodized Al grains labeled with $^{32}P$ for use as $\beta$ sources in interstitial radiotherapy. (C.H.)

**27254** GRIDS TO REDUCE SCATTERED X-RAYS IN MEDICAL RADIOGRAPHY. W. Hondius Boldingh (Technological Universiteit, Eindhoven, Netherlands). Philips Res. Rept., Suppl., No. 1, 1-86(1964).

A study was made of the relation between the constructional properties of x-ray grids and their contrast-improving capacity. Measurements of a number of grids of different construction, under various exposure conditions, by means of electronic measuring equipment and a water phantom are described and discussed. The importance of the lead content is stressed and two new specification values are introduced: the focus-grid distance limits and the contrast-improvement factor, which enable a rational choice of grids for various fields of application. A proposition is given for standardization of exposure tables, as far as indications for the use of grids is concerned, based on the contrast-improvement factor. The compensation of the increase of exposure times and doses due to the use of grids, by an increase of voltage across the x-ray tube, is quantitatively analyzed. (auth)

**27255** COMPLICATIONS AND AFTER-EFFECTS OF RADIOTHERAPY WITH HIGH ENERGIES FOR PULMONARY TUMORS. C. Rimondi and G. Mazzanti (Università, Bologna). Radiobiol. Radioterap. Fis. Med., 18: 397-421 (Nov.-Dec. 1963). (In Italian)

The complications and the after-effects of radiotherapy with high energies ($^{60}Co$ and Van de Graaff 2 Mev) were studied on 207 patients treated for pulmonary neoplasms at the Radium Institute in Bologna from 1959 to 1962. The importance of early complications (pneumonia, bronchopneumonia, and pleural effusions) was slight, due both to their low frequency and their reversibility subsequent to an adequate medical therapy. Late sclerotic manifestations, which were important due to their frequency and their irreversibility, were studied from the radiological and differential-diagnostic standpoint and in connection with the chief causal factors such as field size, dose fractioning. On the basis of the clinical course it was concluded that post-actinic pleuropulmonal fibrosis is an after-effect of irradiation, whose prognostic significance is somewhat favorable. (auth)

**27256** HISTOLOGIC AND CYSTOMETRIC POSTIRRADIATION ALTERATIONS OF THE BLADDER. F. Bono and A. Maver (Universita, Bologna). Radiobiol. Radioterap. Fis. Med., 18: 422-34(Nov.-Dec. 1963). (In Italian)

The histologic and cystometric post-irradiation alterations of the bladder were studied. Telecobalt therapy (5000 rads) was applied to the pelvic pit. Histological and cytometric tests carried out during irradiation (2000, 4000, and 5000 rads) and 1 to 3 months after the treatment, showed that for each post-irradiation alteration of the vesical wall (edema, phlogosis, or sclerosis) there is a corresponding cystometric curve. It was concluded that cystometry is

considered as an important means to check alterations and eventual damages to the bladder during radiation treatment administered for neoplasm of the pelvic pit. (auth)

**27257** CLINICAL EXPERIMENTS WITH A NEW PHENOTHIAZINE COMPOSITION FOR THERAPY OF THE NAUSEA AND VOMITING OF IRRADIATED PERSONS. G. Conte and S. Casara (Radioterapia Dell'Ospedale Civile, Padua). Radiobiol. Radioterap. Fis. Med., 18: 466-74 (Nov.-Dec. 1963). (In Italian)

After studies of the pathogenesis and therapy of nausea and vomiting of irradiated persons, an examination was made of the effects on these symptoms of thiethylperazine. The drug was prescribed to 60 ward patients in the Department of Radiotherapy who were having therapeutical irradiation for neoplastic forms, and in whom sickness and vomiting appeared. Administration of the drug after the appearance of the disturbances gave positive results in 90% of the cases, with excellent tolerance on the part of the patients. (auth)

**27258** 101 PITUITARY ADENOMAS TREATED WITH X-RAYS. Gh. Schmitzer, L. Norz, E. O. Coseru, and V. Grancea (Coltea Radiological Clinic, Bucharest). Radiobiol. Radiotherap., 5: 1-33(1964). (In German)

The case histories are reviewed for 101 cases of pituitary adenoma treated with therapeutic doses of x radiation. The pathology of pituitary adenoma and response to radiation are reviewed. The criteria for x-ray therapy of this tumor are outlined. (C.H.)

**27259** A SIMPLIFIED DOSE CALCULATION IN TELECOBALT THERAPY. W. Kraus (Humboldt-Universitat, Berlin). Radiobiol. Radiotherap., 5: 113-19(1964). (In German)

On the basis of the use of tumor dose-air dose ratios, a simplified method is presented for calculating the tumor dose in stationary field irradiations and the axial dose in rotation therapy with telecobalt units. The method is simple and also more accurate than the method of calculation by means of the relative depth doses. The correction in using non-square fields is discussed. (auth)

**27260** THE EFFECT OF METOTHYRINE TREATMENT IN THE THERAPY WITH IODINE$^{131}$ ON THE RADIOSENSITIVITY OF THE THYROID GLAND. J. Foeldes, I. Krasznai, K. Megyesi, and L. Nagy (Inst. of Pathological Anatomy, Academy of Medicine, Budapest). Radiobiol. Radiotherap., 5: 177-83(1964). (In German)

The radiosensitivity of the thyroid gland in rats was increased by a subsequent metothyrine treatment for three weeks after 150 $\mu$C $^{131}$I had been given. The administration of a quantity of radioiodine alone, or treatment with metothyrine alone, or treatment with metothyrine before treatment with radioiodine had no marked effect on the functional state of the thyroid gland. On the contrary, the thyroid uptake of $^{131}$I in rats was essentially reduced under the effect of metothyrine treatment following the administration of radioiodine. The thyroid gland of these animals did not show any pronounced histological destructions. (auth)

**27261** THE APPLICATION OF $^{170}$THULIUM TO THE DETERMINATION OF EXPOSITION FOR X-RAY PHOTOS. S. Murczynski and H. Mikosza (Rontgeninstitut, Medizinische Akademie, Szczecin, Poland). Radiol. Diagn., 4: 249-56 (1963). (In German)

In order to determine exposure factors, the radioactive isotope $^{170}$Tm was used to define a factor related to the opacity of the object to be photographed. The $\gamma$ emission consists of quanta of 84 kv for the most part; the source was less than 2 mm diameter, including the Al and Plexiglas encasement to remove $\beta$ radiation. Specific activity of $^{170}$Tm may easily reach 1 C/g today, allowing an exposure in 10 to 20 sec. A number of photographs illustrate the similarity between Tm photographs and x-ray photographs; $^{170}$Tm irradiation corresponds to x irradiation at 120 kv filtered with 0.5 Cu. The magnitude of the "patient factor" is a function of the individual; a unit of opacity was defined by measuring Tm radiation after passing through the hand in the dorso-ventral direction in 30 adults; this value is 45.69 ± 3.97 of the incident radiation. Comparison of a photograph of a patient with Albers-Schoenberg disease illustrates the utility of this scale of measurement. A study of various parts of the body in different patients allowed the construction of a chart relating opacity to $^{170}$Tm irradiation to the exposure factor for different photographs; the exposure factor for x rays is approximately four times the Tm factor. An exposure of 15 sec for the photograph exposes the patient to $1/4000$ the dose of $\gamma$ quanta delivered in the usual thorax x-ray photograph. (BBB)

**27262** A TUBERCULOSIS SURVEY SYSTEM USING A PORTABLE RADIOACTIVE SOURCE FOR CHEST RADIOGRAPHY. Frano L. Green (Visco Corp., Detroit), and Kenneth L. Krabbenhoft. Trans. Am. Nucl. Soc., 7: 206 (June 1964).

**27263** PORTABLE CHEST RADIOGRAPHY EQUIPMENT WITH RADIOACTIVE SOURCE FOR TUBERCULOSIS SURVEYS. John H. Allen, Gene P. Graham, William F. Hawkins, and Farno L. Green (Visco Corp., Detroit). Trans. Am. Nucl. Soc., 7: 206-7(June 1964).

**27264** ON DIAGNOSIS OF THYROTOXICOSIS. G. A. Kazaryan. Vopr. Radiobiol., Akad. Nauk Arm. SSR, Sektor Radiobiol., Sb. Tr., 3-4: 217-23(1963). (In Russian)

The hormonal function of the thyroid gland was studied in 955 patients by means of radioactive iodine. Thyrotoxicosis of various degrees of severity was found in 235 patients. When diagnosing an intensified function of the thyroid gland both clinical (basic metabolism, percentage of cholesterol, sugar, residual Ni and Ca) and radioisotope procedures were used to compare the accuracy of the data obtained. The radioactive I absorbability by the thyroid tissue parenchyma was determined 2, 4, 6, and 24 hr after $^{131}$I administration. The excretion of radioactive I with urine and radioactivity of saliva and sweat were also estimated. The clinico-radiological comparison when diagnosing thyrotoxicoses showed the great significance of radioactive I in detecting initial and atypical forms of the thyroid gland functional disorders. (auth)

**27265** DEUTSCHER RÖNTGENKONGRESS 1963. Bericht über die 44. Tagung der Deutschen Röntgengesellschaft (Gesellschaft fur medizinische Radiologie, Strahlenbiologie und Nuklearmedizin e.V.) vom 24. bis 28. April 1963 in Baden-Baden. Teil A. Strahlendiagnostik, Strahlentechnik, und Strahlenphysik (German X-Ray Congress, 1963.) Report on the 44th Session of the German X-Ray Society (Society for Medical Radiology, Radiobiology, and Nuclear Medicine e.V.), April 24-28, Baden-Baden. Part A. Radiation Diagnostics, Radiation Techniques, and Radiation Physics. Supplement to the Journal Progress in the Field of X Radiation and Nuclear Medicine. Stuttgart, Georg Thieme Verlag, 1964. 306p. DM 59. Also available from Intercontinental Medical Book Corp., New York.

The 50 papers presented at the 44th session of the German X-Ray Society and the discussions following the

papers are compiled. The topics considered are malformations in the area of cranium-spinal column transformation and their diagnostic and clinical importance, pulmonary mycosis, radiation burden of patients, physics and technology, and nuclear medicine. Individual abstracts were prepared for 12 of the papers. (J.S.R.)

*For abstracts of individual papers see: 27266, 27267, 27268, 27269, 27270, 27271, 27272, 27273, 27274, 27275, 27276, and 27277.*

**27266** EXPERIMENTAL STUDIES ON THE QUESTION OF PATIENT DOSIMETRY IN X-RAY DIAGNOSIS. E. Bunde (Universität, Munich). p.153-64 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

The necessity for measurement of the dose received by patients during diagnostic radiographic examinations is briefly summarized. The characteristics required for instruments to measure the radiation burden in diagnosis are tabulated and discussed. The measurement units to be considered in patient dosimetry are incident dose, incident surface dose, irradiation energy, integral dose, and absorbed energy. Studies made in the measurement of each of these units are reported. (J.S.R.)

**27267** THE TECHNICAL POSSIBILITIES OF DIAGNOSTIC DOSIMETRY. E. Zieler (Laboratorium der C.H.F. Mueller GmbH, Hamburg). p.165-70 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

The three measurement magnitudes of most significance in diagnostic dosimetry are surface dose, irradiation energy (the analog integral of the energy flux density), and the volume dose. The determination of the volume dose is briefly discussed, and the other two measurements for which commercial measurement devices are available are considered. The characteristics of some of the instruments available are reported. (J.S.R.)

**27268** THE MEASUREMENT PRINCIPLES OF PATIENT-DOSE MONITORS. H. Berger and W. Fussangel (Siemens-Reiniger-Werke AG, Erlangen, Ger.). p.171-6 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

The principles of two types of devices used for the monitoring of patient dose during diagnostic radiographic examinations are reported. The characteristics of these monitors and possible variations on them to improve the determination of the irradiated energy are discussed. (J.S.R.)

**27269** A DIAGNOSTIC DOSIMETER—BASIC FORM AND MODIFICATIONS. H. Pychlau and P. Pychlau. p.177-80 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

Some criteria for a diagnostic dosimeter, obtained from practical experience and from research, are reported. The design and operation of the Diamentor, a commercially available dosimeter, are discussed. (J.S.R.)

**27270** PRELIMINARY RESULTS OF A SURVEY ON THE RADIATION BURDEN OF PATIENTS IN IRRADIATIONS WITH AND WITHOUT PRECISE EXPOSURES. D. Schoen and G. Griesser (Universität, Tübingen, Ger. and Chirurgische Universitätsklinik, Tübingen, Ger.). p.181-9 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

A survey was made by the radiological institutes of Tübingen University and some hospitals in Germany and Switzerland to determine the radiation exposure of patients in irradiations with and without precise focusing. The preliminary results obtained from the survey are reported. The survey factors discussed are the selection of the random sampling, mean value of irradiation time and surface dose, relation between irradiation time and surface dose, relation between sex of patient and surface dose, effect of irradiation conditions, effect of previous x-ray studies on the surface dose, effect of the clinical and radiological conditions on the surface dose, and relation between surface and gonal dose. (J.S.R.)

**27271** APPARATIVE HYPOTHESES FOR AN IMPROVED RADIATION PROTECTION. K. Reinhardt (Huttenkrankenhauses, Volklingen/Saar, Ger.). p.190-1 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

The manner in which radiation damage can occur at the present during radiodiagnosis or radiotherapy is illustrated by examples. Three proposals are offered to reduce the accidental exposure from radiation leakage and insufficient shielding. (J.S.R.)

**27272** IS X-RAY STUDY OF THE APPENDIX AN UNNECESSARY RADIATION BURDEN? H. Birzle and M. Oertmann (Chirurgische Universitatsklinik, Freiburg i.B.). p.192-4 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

The question of the necessity of x-ray diagnosis of the appendix as a preliminary to surgery was investigated by a study of 150 cases. The x-ray studies were compared with the surgical and histological findings. The samples included children, adolescents, and adults of all ages. The agreement of the x-ray diagnosis with the surgical and histological results was 96%. The surface radiation burden was smallest in the appendix exposures alone, significantly larger in the gastrointestinal exposures, and largest in contrast enema. The gonad dose followed the surface dose ratios. It was concluded that, in cases where the clinical results are uncertain, radiodiagnosis is a valuable auxiliary. (J.S.R.)

**27273** CIRCULATORY DIAGNOSIS OF HEART AND LUNGS WITH RADIOISOTOPES. H. Hundeshagen (Philipps-Universität, Marburg/Lahn, Ger.). p.243-50 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

Although other clinical radiodiagnostic methods with radioisotopes find routine application, heart and lung circulatory diagnosis with radioisotopes is still in a certain development stage. The principal studies on the diagnosis of heart and lung functions using radioisotopes and the results obtained are summarized. 48 references. (J.S.R.)

**27274** INVESTIGATIONS OF THE PERIPHERAL CIRCULATION WITH RADIOACTIVE MATERIALS. W. Schumacher (Stadtische Rudolf-Virchow-Krankenhauses, Berlin). p.251-8 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

The application of radioactive materials in circulatory diagnostics has brought new knowledge to the evaluation of circulatory illnesses. Some of the test methods developed have been used in many clinics and can be considered as routine diagnostic methods. The development of these methods and their areas of use are reviewed. 55 references. (J.S.R.)

**27275** ISOTOPE STUDIES OF THE LIVER BLOOD FLOW AND ITS MODIFICATION BY PARTIAL-BODY IR-

RADIATION. H. W. Pabst and J. Klemm (Universität, Munich). p.259-62 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

The modification of the liver blood flow by partial-body irradiation was studied in patients in whom tumor therapy with partial-body irradiation or with isotopes was carried out. The studies were made on a total of 233 patients before, during, and after radiotherapy. The results showed, in general, that partial-body irradiation did not lead to damage of liver function. The statistically observed increase in bromsulphalein retention in irradiation in the head-throat region is the expression, as animal experiments with radiogold clearance have shown, of a modified liver blood flow. This blood flow alteration is induced by the special sensitivity of nerve centers as well as of endocrine glands in the irradiation region. (J.S.R.)

**27276** STUDIES ON THE DETECTION OF THE CEREBRAL BLOOD FLOW WITH $I^{131}$-LABELED SERUM ALBUMIN. E. Scherer, W. Stroetges, and G. Hagemann (Stadtische Krankenanstalten, Essen, Ger.). p.263-7 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

The tracer methods used for determination of the cerebral blood flow are briefly reviewed with emphasis on the methods using $^{131}I$-labeled serum albumin. The principles of the intravenous injection of $^{131}I$-albumin with measurement in the occiput and throat regions are given together with typical results. 16 references. (J.S.R.)

**27277** CLEARANCE DETERMINATIONS IN SKIN GRAFTS WITH THE HELP OF RADIOSODIUM AND RADIOIODIDE. E. J. Nagy and J. Galambos (Research Inst. for Radiological Medicine, Hungarian Academy of Sciences, Budapest). p.268-71 of "Deutscher Röntgenkongress 1963." Stuttgart, Georg Thieme Verlag, 1964. (In German)

The isotope clearance method recommended for the control of the venous circulation in skin grafts was critically evaluated. The studies carried out with $^{24}Na$ and $^{131}I$ confirm that this method yields reliable quantitative results on the blood supply of the grafts. The resorption half life calculated on the basis of the measurement results and the clearance speed gives objective evidence on the viability of the grafts. (tr-auth)

# CHEMISTRY

## General

**27278** (HW-79280(p.4.1-28)) CHEMICAL RESEARCH AND DEVELOPMENT. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Installation of engineering-scale equipment in the High-Level Radiochemistry Facility was completed. Hypochlorite Destruction Tests. Hypochlorite was removed by reaction with hydrogen peroxide. Salt Cycle Flowsheet Studies. Plutonium removal by codeposition techniques does not have a "cut off" plutonium concentration. Chloride Contamination in Electrolytic $UO_2$. Present techniques reduced chloride concentration to 50 ppm from $UO_2$ samples originally containing 100 to 1000 ppm. Electrochemistry of Uranium in Molten Chloride Salt Solutions. The reaction $UO_2 + Cl_2 \rightarrow UO_2Cl_2$ was studied. Full-Level Pilot Plant Calcination Studies. Addition of sugar to provide a reducing atmosphere during calcination improved ruthenium removal by a factor of 4. Spray Calcination of Purex Waste Plus Phosphate. Waste calcined with phosphate showed fission product behavior similar to acidic Purex waste with no additives. Iodine Behavior in Spray Calcination. Indications are that 80% of the iodine is volatilized from the calcine and that only part of it is recovered in the condenser system. Radiant Heat Spray Calciner. Capacity, recirculation rate, and heat transfer characteristics were calculated. Filter Blow-Back Study. The data indicate little effect of nozzle to venturi distance when the nozzle is from 2 to 6 in. from the venturi throat. Calcine Powder Melter. A hard but deliquescent solid, density 2.7 g/cm$^3$, was formed from feed of bulk density <0.5 g/cm$^3$. Denitrator Evaporator. Studies in support of design of a denitrator evaporator were initiated. Fundamental Sorption Research. Rational thermodynamic equilibrium constants and standard Gibbs free-energies were determined for two exchange reactions with the zeolites Linde 4AXW, 13X AW-400, AW-500, Norton Zeolon, and clinoptilotite. Low- and Intermediate-Level Waste Treatment. Batch equilibrium experiments were conducted to determine the uptake of trace ruthenium from steam stripped high-level alkaline waste condensate by several anion exchange resins. (auth)

**27279** (HW-80284(p.4.1-23)) CHEMICAL RESEARCH AND DEVELOPMENT. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Salt Cycle Process Engineering Development. Test runs of the High Level Radiochemical Facility for processing of irradiated $UO_2$–$PuO_2$ fuel from the PRTR were made. Radioactive Residue Process Development. A sample of Redox waste and a fresh quantity of raw Purex waste (not formaldehyde treated) were analyzed. The Redox waste was spray calcined with glass forming additive. The Purex waste was calcined after most of the acid was destroyed by digestion with sugar. A spray calcination run was made with phosphite added to the Purex waste. A further run was made with the Purex waste with cold fission products to simulate high burnup. Large diameter draft tubes, with and without fins, were studied to determine their effects on recirculation rates and feed capacities for the Cold Semiworks Radiant Heat Spray Calciner. Filter blow-back overpressures were measured for various nozzle sizes, venturi shapes, filter permeabilities, and blow-back air flow rate for off-gas filtration for spray calciners. The effects of composition on melting point, phase separation, and solubility were studied for three types of glass systems: Purex-phosphate with phosphate additions; higher phosphate types; and a system containing lithium, calcium, and aluminum additions to reduce the volatilization of sulfates. Work on the process and equipment for the hot cell glass experiment for the conversion of actual high-level wastes to glassy solids continuously was carried out. The capacity of the continuous calciner melter was studied using nonradioactive Redox- and Purex-type wastes; corrosion of the Inconel melter pot was found. The development of the Fuels Recycle Pilot Plant is discussed. Thermodynamic data are given for ion-exchange materials; zeolite, phillipsite, etc. The performance of a three-bed demineralizer for steam-stripped alkaline (Purex tank farm) condensate is demonstrated. (R.E.U.)

**27280** (ORNL-3597) TRANSURANIUM QUARTERLY PROGRESS REPORT FOR PERIOD ENDING NOVEMBER 30, 1963. W. D. Burch, comp. (Oak Ridge National Lab., Tenn.). May 1964. Contract W-7405-eng-26. 78p.

Progress is reported on the development of separation processes for the transuranium elements, process equipment, design, development and fabrication, HFIR target fabrication development, construction of the TRU Processing Plant, corrosion studies, and analytical research and development. (J.R.D.)

**27281** (UCRL-11295) OPTIMUM PROPORTIONAL CONTROL OF A BLENDING PROCESS USING IMPRECISE FEEDBACK INFORMATION. Carl N. Taylor and Alan Foss (California. Univ., Berkeley. Lawrence Radiation Lab.). Feb. 17, 1964. Contract W-7405-eng-48. 53p.

This experimental study verifies the applicability of Acrivos's analysis of linear processes to a randomly disturbed continuous liquid blender which blends water and a salt solution. The process is controlled by a simple proportional controller which is fed imprecise feedback information. Evaluation of process performance is based on the time-averaged value of the square of the concentration fluctuations of the blended stream. Calculation of the mean-square-concentration fluctuations by Acrivos' method shows the mean-square deviations to be a function of loop gain, the relative magnitude of the measurement error and the effluent concentration fluctuations at zero control, the relative-frequency content of the measurement error and the input disturbance signals, and natural damping-frequency characteristics of the blending process. The predictions of process performance calculated by this method are verified by the experimental results, which show that the mean-square deviations cannot be reduced to zero, but rather a minimum value is obtained as the amount of control action is varied. This minimum results from the counteraction of the favorable effect of feedback of the concentration measurement and the undesirable effect of measurement error. In general, use of proportional control in this type of problem would greatly improve process performance when measurement error is either small or high-frequency in nature. When the measurement error is large, proportional control is ineffective and other types of control action are recommended. (auth)

**27282** "COMPOUNDS"(?) OF THE NOBLE GASES PRIOR TO 1962. Cedric L. Chernick (Argonne National Lab., Ill.). J. Chem. Educ., 41: 185-6(Apr. 1964).

A brief review is presented on developments in rare gas compounds prior to 1962. The developments consisted primarily of predictions. Despite much hard and exhaustive work, the position early in 1962 was that no unrefutable proof had been given for the existence of a compound in which a noble gas was chemically bound to another entity. Helium, Ne, Ar, Kr, Xe, and Rn were considered inert gases. (P.C.H.)

**27283** THE RARE-EARTH ELEMENTS. D. N. Trifonov. Pergamon Press Book. New York, Macmillan Co., 1964. 128p.

Chemical and physical properties are presented for rare-earth elements along with their preparation and separation, and their application as addition elements to steels. (Rev. Metal Lit., 21: No. 5, May 1964)

## Analytical Procedures

**27284** (AMRA-MS-63-01) EMISSION SPECTROGRAPHIC SOLUTION TECHNIQUES WITH APPLICATIONS TO THE ANALYSIS OF URANIUM AND TITANIUM ALLOYS. W. K. Murray (Army Materials Research Agency. Metals and Ceramics Research Labs., Watertown Arsenal, Mass.). June 1963. 12p. (CONF-48-7)

From Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Mar. 1963.

The matrix effect on spectrographic solution analysis of alloys was studied using Ti and Fe as matrices and was found to be negligible. The effects of acid concentration and excitation index were also determined. Applications of spectrographic solution techniques to Ti and U alloys are described briefly, and the electrical parameters, exposure conditions, and line pairs are tabulated. (D.L.C.)

**27285** (AWRE-O-10/64) THE ASSAY OF PLUTONIUM—A CRITICAL EXAMINATION OF ACCURATE ANALYTICAL METHODS FOR PLUTONIUM. R. F. Coleman and J. B. Hornsby (United Kingdom Atomic Energy Authority. Weapons Group. Atomic Weapons Research Establishment, Aldermaston, Berks, England). Mar. 1964. 19p.

Several chemical methods of assaying plutonium were examined critically in order to find the most suitable one for routine use at AWRE. The titration of plutonium III to IV with ceric sulphate, following the reduction of plutonium by titanous chloride, appears to be the best. The optimum conditions for this method were determined and also the effect of impurities. The accuracy and precision of this procedure has been carefully evaluated; the standard deviation of one determination is 0.06% and there is no detectable bias. (auth)

**27286** (CEA-2367) DOSAGE DE L'OXYGENE DANS LES COMPOSES DE L'URANIUM PAR LA METHODE AU MONOCHLORURE DE SOUFRE. (Determination of Oxygen in Uranium Compounds Using a Sulfur Monochloride Method). Guy Baudin, Jean Besson, Pierre-Lazare Blum, and Tran-Van-Danh (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucleaires, Grenoble). Apr. 1964. 9p.

A method for oxygen determination in U compounds uses $S_2Cl_2$ to attack the sample to form $SO_2$ which is then measured. Experimental aspects (apparatus and procedure) of the method are given. (D.L.C.)

**27287** (DP-886) SEQUENTIAL ANALYSIS OF RADIONUCLIDES IN HEAVY WATER MODERATOR. H. Perry Holcomb (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). May 1964. Contract AT(07-2)-1. 12p.

A method was developed for determining the following seventeen gamma-emitting radionuclides in moderator samples: $^{103}Ru$, $^{106}Ru$, $^{131}I$, $^{133}I$, $^{95}Zr$, $^{95}Nb$, $^{97}Zr$, $^{97}Nb$, $^{239}Np$, $^{56}Mn$, $^{51}Cr$, $^{141}Ce$, $^{143}Ce$, $^{91}Sr$, $^{92}Sr$, $^{140}Ba$, and $^{24}Na$. The radionuclides are separated sequentially into six groups by solvent extraction and ion exchange. The activities of each fraction are determined by gamma counting and gamma spectrometry. Average recoveries from seven synthetic samples that contained ten representative radionuclides were 89 to 114% with an average material balance of 96%. Analyses of reactor moderator samples showed good agreement between the sequential method of analysis and individual analyses of the radionuclides. (auth)

**27288** (KFK-199) BESTIMMUNG DER SPEZIFISCHEN AKTIVITÄT EINIGER RADIONUKLIDE. (Determination of the Specific Activity of a Radionuclide). H. Ruf and H. Muenzel (Kernforschungszentrum. Institut fur Radiochemie, Karlsruhe, Germany). Feb. 1964. 45p.

A method is described for determining the yield and specific activity of the fission products $^{144}Ce$, $^{89}Sr$, $^{90}Sr$, $^{99}Tc$, $^{95}Zr$, $^{95}Nb$, $^{106}Ru$, $^{103}Ru$, $^{131}I$, and $^{137}Cs$. The yield determination is based on the method of gravimetric analysis with the use of paper filters. The conditions for the necessary weight constant of the paper filters were worked out. Determination of the absolute decay rate in the measurement preparation depended on the determination of the operation stages of the counter by means of activation, which was standardized by the 4-$\pi$ method. (tr-auth)

**27289** (NYO-10497) HIGH-ALTITUDE BALLOON SAMPLING PROGRAM. SECOND QUALITY CONTROL. Progress Report. Fernando Bazan, Philip W. Krey, and Colin G. Sanderson (Isotopes, Inc., Westwood, N. J.). May 21, 1964. Contract AT(30-1)-3276. 29p.

The analytical work conducted between July 1 and Dec. 31, 1963, is described. Blank and spiked samples were analyzed for nuclides. A cross-calibration sample was also analyzed, and a dilution study was performed on $^{89}Sr$, $^{90}Sr$, and $^{95}Zr$. The results are tabulated. (D.L.C.)

**27290** (TID-19180) A SIMPLIFIED DETERMINATION OF GASES IN WATER. D. L. West (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). July 1963. Contract AT(07-2)-1. 10p.

A method for the determination of dissolved gases (He, $H_2$, $O_2$, $N_2$, etc.) in water is given which can detect concentrations as low as 5 to 30 ppb. In this method, the gases are extracted from the water into a known amount of pure gas, and the resulting gas mixture is analyzed by mass spectrometry. The various factors affecting the sensitivity of the method are discussed, and the calculation of extraction efficiency is considered. The application of the method to other liquids is also considered. (D.L.C.)

**27291** (Y-DA-590) DETERMINATION OF ALUMINUM AND SILICON IN BERYLLIUM BY X-RAY FLUORESCENCE. G. E. Walden, Alma D. Condrey, and Katherine A. Sells (Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.). Apr. 2, 1964. Contract W-7405-eng-26. 14p.

A vacuum x-ray fluorescence method was developed for routine analysis of up to 1.0% Al and 0.25% Si in Be. The equipment and reagents used, sample preparation, analysis procedure, and calibration procedure are outlined. Results of analysis of standards are given. (D.L.C.)

**27292** (ORNL-tr-186) TRACE DETECTION IN GAS CHROMATOGRAPHY WITH A FLAME IONIZATION DETECTOR AND A PACKED SEPARATION COLUMN. U. Schwenk, H. Hachenberg, and M. Forderreuther. Translated by Kenneth S. Warren (Oak Ridge National Lab., Tenn.), from Brennstoff-Chem., 42: 295-6(1961). 5p.

The determination of quantities of less than 1 ppm CO and $CO_2$ in ethylene involved hydrogenation of the latter to methane which in turn can be detected with great sensitivity with a flame ionization detector. Propylene, in the trace range, overlaps with the ethylene peak in ordinary column packing. Columns filled with metal olefin complexes provide greater sensitivity. (auth)

**27293** RESISTOMETRIC AND NEUTRON ACTIVATION ANALYSIS OF ALUMINUM DURING ZONE REFINING. D. Gelli, R. Malvano, and N. Sacchetti. Alluminio, 32: 481-7(Oct. 1963). (In Italian)

Resistometric measurements and neutron irradiation analysis were performed on zone melted Al to determine its purity, and distribution of Cu, Mn, W, and other elements. (Rev. Metal Lit., 21: No. 5, May, 1964)

**27294** A WET-COMBUSTION METHOD FOR CARBON-14 ANALYSIS. Adrian C. Kuyper, Thomas A. Cortese, and Mohsen Aghdashi (Wayne State Univ., Detroit). Anal. Biochem., 8: 272-5(June 1964).

A procedure that uses forced circulation in a closed system at slightly reduced pressure and in which acids and halogens are washed out of the $CO_2$ was developed for the determination of $^{14}C$. From 0.1 to 1.0 mmole of C and about 14 min are required for each combustion. The apparatus and procedure are described. (P.C.H.)

**27295** IMPROVED IONIZATION CROSS-SECTION DETECTORS. J. E. Lovelock, G. R. Shoemake, and Albert Zlatkis (Univ. of Houston, Tex.). Anal. Chem., 36: 1410-15 (July 1964).

The ionization cross-section detector is recognized as one of the few unequivocal detection devices available for use in gas chromatography. The use of an integral pair ionization cross-section detector makes it possible to utilize the desirable characteristics associated with this detection method at reduced pressures, for programmed temperature and pressure (or flow programmed operation) without the accompanying deficiencies often encountered with other detection systems. A micro cross-section detector was developed with a total volume of 8 μl. This cell is used to provide cross-section responses for components emerging from 0.01 inch diameter capillary chromatographic columns, thus extending the range of application of ionization cross section. The foregoing detectors are readily adaptable to the constraints imposed on a flight model chromatograph for interplanetary exploration. The value Q, the cross section for ionization for elements, can be experimentally determined and calculations applied that allow the determination of the mass of component represented by any chromatographic peak. (auth)

**27296** APPLICATIONS OF ISOTOPIC EXCHANGE IN GAS CHROMATOGRAPHY. Jacob Tadmor (Soreq Research Establishment, Yavne, Israel). Anal. Chem., 36: 1565-73 (July 1964).

Isotopic exchange in gas chromatography was studied and applied to labeling of inorganic compounds, analytical determination of inorganic compounds separated by gas chromatography, and a study of the interaction between the solid stationary phase and the solute in gas liquid chromatography. By gas chromatography isotopic exchange, the use of a radioactivity detector is made possible, without the introduction of radioactive metal compounds as starting materials. $GeCl_4$, $SnCl_4$, $AsCl_3$, and $FeCl_3$ were labeled and determined by using $^{36}Cl$ labeled Sil-O-Cel as the solid stationary phase. Gas liquid chromatography experiments showed that even after coating the radioisotope labeled solid stationary phase with a thin liquid layer, isotpe exchange still occurs between the $^{36}Cl$ sorbed on the solid phase and the gaseous inorganic compound sample, indicating that the solid support is not always inert. For a given surface area of the solid support both the isotopic exchange and the number of theoretical plates increase with the decrease of its specific porosity and tortuosity coefficient. More highly polar liquids reduced the isotopic exchange to a greater extent than liquids of low polarity. (auth)

**27297** ACTIVATION ANALYSIS BY ABSOLUTE GAMMA-RAY COUNTING AND DIRECT CALCULATION OF WEIGHTS FROM NUCLEAR CONSTANTS. Francesco Girardi, Giampaolo Guzzi, and Jules Pauly (Centro Commune di Ricerche Euratom, Ispra, Italy). Anal. Chem., 36: 1588-94(July 1964).

A method based on neutron activation and gamma spectrometry was studied by irradiating samples of different elements, measuring the activities by means of a calibrated gamma spectrometer, and calculating the weights of elements from the activation formula. The values obtained were compared with the weights of the irradiated samples. Then accuracy and precision were evaluated. The results show that random errors generally are not greater than those obtained by using the relative method, but that systematic errors may reach 20%, although in 11 cases out of 13 they were lower than 10%. Different causes of error were evaluated. Calibration of the gamma spectrometer and neutron flux measurements do not cause any relevant error. Uncertainties in nuclear data taken from literature, especially those on decay schemes and activation cross sections, may be responsible for most systematic errors. If the nuclear constants are known and the precision required is not better than 20%, the method can be applied to trace analysis by neutron activation and the experimental procedures considerably simplified. (auth)

**27298** DETERMINATION OF ZINC IN ORES AND MILL PRODUCTS BY NEUTRON ACTIVATION ANALYSIS. J. M. Bakes and P. G. Jeffery (Warren Spring Lab., S.S.I.R., Stevenage, Herts, Eng.). Anal. Chem., 36: 1594-7(July 1964).

Samples of ores and mill products with widely different zinc content were analyzed by neutron activation. In cases where the separation of zinc in a radiochemically pure state was required, an ion-exchange separation was used and the zinc precipitated with quinaldic acid. The activities of both zinc-69m and zinc-65 were measured, using beta and gamma counting methods. Gamma spectrometry on unprocessed irradiated material was also used. The results were compared with those obtained by polarographic and titrimetric methods. (auth)

**27299** DETERMINATION OF THE ZINC-68-ZINC-64 RATIO IN ROCKS AND MINERALS BY NEUTRON ACTIVATION ANALYSIS. R. H. Filby (Universitet, Oslo). Anal. Chem., 36: 1597-1600(July 1964).

A neutron activation method for the microdetermination of the $^{68}Zn/^{64}Zn$ ratio in rocks and minerals is described and discussed. Samples are irradiated in a thermal neutron flux of approximately $10^{12}$ neutrons per $cm^2$ per second and

dissolved, inactive zinc carrier is added, and the zinc is separated in a radiochemically pure state by anion exchange and ferric hydroxide scavenging. The $^{69m}Zn/^{65}Zn$ activity ratio (relative to a standard zinc oxide sample) gives a measure of the $^{68}Zn/^{64}Zn$ ratio. Precision ranges from 0.3% (relative standard deviation) for samples with high zinc contents to approximately 1% for samples with low zinc contents. The sensitivity is estimated as 0.4 ppm of zinc. The method is rapid, specific, and not subject to serious contamination problems. Results for a sphalerite, granite G-1, and diabase W-1 indicate that there is no significant difference in the $^{68}Zn/^{64}Zn$ ratios relative to the standard zinc. (auth)

**27300** RADIOCHEMICAL DETERMINATION OF RADIUM-228 AND THORIUM-228 IN BIOLOGICAL AND MINERAL SAMPLES. Henry G. Petrow, Arthur Cover, Walter Schiessle, and Elizabeth Parsons (New York Univ., Tuxedo). Anal. Chem., 36: 1600-3(July 1964).

A general radiochemical procedure for the determination of radium-228 and thorium-228 in biological and mineral specimens was developed. The technique is sensitive and as little as 1 $\mu\mu$C of radium-228 and 0.02 $\mu\mu$C of thorium-228 can be detected. Samples containing as much as 50 grams of ash can be treated without adverse effects from either phosphate ion or calcium ion. Interference from other radioactive substances normally present in the environment is negligible. (auth)

**27301** ANION EXCHANGE SEPARATION OF RHENIUM FROM MOLYBDENUM AND TECHNETIUM IN THIOCYANATE CHLORIDE MEDIA. Hiroshi Hamaguchi, Kazuaki Kawabuchi, and Rokuro Kuroda (Tokyo Kyoiku Univ.). Anal. Chem., 36: 1654-6(July 1964).

A systematic study of the adsorption of Re(VII) with a strongly basic anion exchanger, Dowex 1-X8, in $NH_4SCN$–HCl medium indicates that the difference in the equilibrium distribution coefficients of Re(VII) and either Mo(VI) or Tc(VII) is large enough for sharp separation. An anion exchange chromatographic procedure was developed for the separation of Re(VII) from Mo(VI) or Tc(VII). Re(VII) is first eluted with 0.5M $NH_4SCN$–0.5M HCl solution while Mo(VI) or Tc(VII) remains adsorbed strongly on the column. Mo(VI) is then removed quantitatively by passing 2.5M $NH_4NO_3$ solution through the column. A 0.5M NaOH–0.5M NaCl solution is preferable to $NH_4NO_3$ when large amounts of Mo(VI) are present. Tc(VII) is eluted with 4M $HNO_3$ solution, which gives a Tc(VII) recovery of about 60%. Microgram to a few milligram quantities of Re(VII) can be quantitatively separated from Mo(VI) in proportions of Re : Mo = 1 : 500 to 170 : 1 and from tracer quantities of Tc(VII). (auth)

**27302** SPECTROPHOTOMETRIC DETERMINATION OF FLUORIDE BY ZIRCONIUM–ERIOCHROME CYANINE R. P. L. Sarma (Univ. of North Dakota, Grand Forks). Anal. Chem., 36: 1684-5(July 1964).

An investigation was made to determine the fluoride concentration that is most suitable for determination using original and modified Zr-Eriochrome Cyanine R reagents. The feasibility of simplifying the determination by use of a factor instead of a calibration curve was also studied. The reagent was found suitable for the determination of about 1.0 to 1.4 ppm of fluoride. Modifications of the reagent were found suitable for 2.0 and 3.0 ppm of fluoride. It was concluded that within these ranges a fluoride could be determined using a factor instead of a calibration curve. (P.C.H.)

**27303** NEW DESIGN OF AN INTERNAL PROPORTIONAL FLOW COUNTER FOR RADIO-GAS CHROMATOGRAPHY. F. Schmidt-Bleek and F. S. Rowland (Univ. of Kansas, Lawrence). Anal. Chem., 36: 1695-6(July 1964).

The design and properties of a brass-Teflon counter for radio-gas chromatography are given. The counter can be used at elevated temperatures (tested up to 160°C), background is low even without further shielding, counting volume can readily be adjusted by variation of the cathode length, and the counter is virtually indestructible. The counter was constructed from inexpensive materials with simple machinist's tools at a cost of less than $100. (P.C.H.)

**27304** DETERMINATION OF OXYGEN IN URANIUM COMPOUNDS BY REACTION WITH SULFUR MONOCHLORIDE. G. Baudin, J. Besson, P. L. Blum, and Tran Van Danh (Centre d'Etudes Nucleaires, Grenoble, France). Anal. Chim. Acta, 30: 443-9(May 1964). (In French)

A sulfur monochloride method is proposed for the determination of oxygen in uranium compounds. Sulfur monochloride reacts with oxygenated compounds at various temperatures, depending upon their nature; the sulfur dioxide produced is titrated by iodometry, after the excess reagent is eliminated by a selective adsorption–desorption process using activated charcoal. This method was successfully applied to uranium oxides ($UO_2$,$U_3O_8$), to mixtures of uranium dioxide with uranium, uranium nitride, and uranium carbide, and to substituted carbides ($UC_{1-x}O_x$). The results were generally satisfactory for oxygen contents higher than 500 ppm. However, in the presence of free or combined carbon, this limit was considerably higher. A loss of oxygen as carbon monoxide was possible, and a simultaneous determination of carbon monoxide had to be carried out. The relative error was of the order of a few per cent. (auth)

**27305** THERMOGRAVIMETRIC INVESTIGATION OF THE ALKALI METAL DILITURATES. Milton W. Goheen and Rex J. Robinson (Univ. of Washington, Seattle). Anal. Chim. Acta, 30: 460-5(May 1964).

Thermolysis curves for lithium, sodium and cesium diliturates were obtained. Lithium and sodium diliturates formed monohydrates from aqueous solutions while potassium, rubidium, and cesium diliturates were anhydrous. The cesium and rubidium diliturates formed rapidly, were quite dense, and easily handled. Both diliturates were thermally stable to about 300°. Methods for the thermogravimetric determination of rubidium and cesium were developed and found to be quite accurate. (auth)

**27306** THE APPLICATION OF ISOTOPIC DILUTION ANALYSIS TO THE FLUORIMETRIC DETERMINATION OF SELENIUM IN PLANT MATERIAL. Peter Cukor, Joseph Walzcyk, and Peter F. Lott (St. John's Univ., Jamaica, N. Y.). Anal. Chim. Acta, 30: 473-82(May 1964).

A method was developed for the fluorimetric determination of selenium in plant material using the reagent 2,3-diaminonaphthalene. Oxygen-flask combustion was used to oxidize plant material. Isotopic dilution techniques were incorporated to account for loss in different stages of the procedure. Measurements were also made on the suitability of several other amines as reagents for selenium. (auth)

**27307** SYSTEMATIC ERRORS IN THE ABSOLUTE DETERMINATION OF DEUTERIUM IN ORGANIC COMPOUNDS. P. Jordan (Eidgenossische Technische Hochschule, Zurich). Anal. Chim. Acta, 30: 515-18(June 1964). (In German)

Systematic errors that may affect the determination of the absolute deuterium content of organic compounds were studied. An empirical procedure for eliminating them is discussed. (auth)

**27308** THE SPARINGLY SOLUBLE SALTS OF LANTHANIDES WITH BENZENEPHOSPHONIC AND BENZENEPHOSPHINIC ACID. A. K. Mukherji (Louisiana State Univ., New Orleans). Anal. Chim. Acta, 30: 591-3(June 1964).

Preliminary investigations showed the possibility of using benzenephosphonic and benzenephosphinic acids as precipitants for the lanthanide ions. The reaction sensitivity was determined for both acids. The sensitivity for the detection of the lanthanides did not show any order. Benzenephosphinic acid in general showed a lower order of sensitivity than benzenephosphonic acid. This could be due to differences in the basicity of the acids or the association of molecules or both. (P.C.H.)

**27309** ALPHA SPECTROMETRY OF SOME ISOTOPES OF NATURAL THORIUM BY THE METHOD OF NUCLEAR EMULSIONS. Giovanni Faraone, Marcello Trozzi, and Vittorio Ricevuto (Università, Messina, Italy). Atti Soc. Peloritana Sci. Fis. Mat. Nat., 8: 517-26(1962). (In Italian)

The isotopic analysis of a natural Th sample was carried out by means of an alpha spectrometry of emissions following the method of a double nuclear emulsion. An equation for the calculation of the energy of $\alpha$ particles was found from the range of the tracks in the emulsion. (auth)

**27310** ANALYTICAL METHODS BASED ON THE REFLECTION AND ABSORPTION OF RADIOACTIVE RADIATION. I. UTILIZATION OF THE REFLECTION OF BETA RAYS DURING THEIR INTERACTION WITH MATTER IN ANALYSIS. P. Schiller and J. Majer (Comenius Univ., Bratislava). Cesk Farm., 11: 286-91(July 5, 1962). (In Czech.)

Analytical methods based on reflection (backscattering) of radioisotope radiations are described. The principles of reflection of radioactive radiation from various substances and the mathematical relations making possible the use of these principles for analytical determination are given. The apparatus used in the experimental work is described. The dependence of the reflection phenomenon on the concentration of Bi in some pharmacologic preparations and drugs was studied, and a linear dependence was found in the samples examined. The effect of other components present on the determination of Bi was also studied; results of these experiments demonstrated that those components studied, formed of elements of low atomic number, do not interfere with the results of measurement by this technique. The information obtained indicates that nondestructive analytical methods based on the reflection of beta particles will be particularly useful in control operations in pharmaceutical production. (BBB)

**27311** RADIOMETRIC TITRATION. NEW POSSIBILITIES. T. Braun (J.-Eotvos Univ., Budapest). Chim. Anal. (Paris), 46: 61-71(Feb. 1964). (In French)

The indication of the equivalent point of reactions used in volumetric analysis, using radioisotopes, has been used up to the present only in the case of precipitation reactions and the formation of complexes extractable with organic solvents. Some new possibilities for the extension of radiometric titrations to formation reactions in aqueous solutions and to redox reactions are described. A new principle is described on the basis of which it is possible to use nonisotopic indicators in heterogeneous phase. According to the theoretical considerations described, radiometric titration can be used in all cases of volumetric reactions. A procedure for the separation of phases is also described. It can be used in all radiometric titration methods by precipitate formation. As examples, the results of the radiometric titration of Ca, Sr, Mg, Zn, and Cu in pure solutions and of Cu in brasses and bronzes are given. (tr-auth)

**27312** GAMMA SPECTROMETRY. ITS APPLICATION TO THE DETERMINATION OF VERY SLIGHT TRACES. F. Dugain (Compagnie Pechiney, Grenoble, France). Chim. Anal. (Paris), 46: 179-87(Apr. 1964). (In French)

The principles, difficulties, applications, and merits of neutron activation analysis are reviewed. Reactions, relations, gamma spectra, sensitivity, reproducibility, radiochemical separations, and spectral analysis are briefly covered, together with the applicability of the technique to various elements. (D.C.W.)

**27313** SEPARATION AND MEASUREMENT OF CESIUM 137 AND BARIUM 137 IN RADIOACTIVE EFFLUENTS. J. Scheidhauer and L. Messainguiral (Centre de Marcoule, France). Chim. Anal. (Paris), 46: 192-5(Apr. 1964). (In French)

A method is described for separating $^{137}Cs$ in effluents and measuring its activity. (D.C.W.)

**27314** A SIMPLIFIED DIFFUSION APPARATUS FOR LIQUID SCINTILLATION COUNTING. Jack C. Towne, E. F. Krohn, and M. Brandfonbrener (Veterans Administration Research Hospital, Chicago and Northwestern Univ., Chicago). Clin. Chim. Acta, 9: 566-71(June 1964).

A screw cap jar was adapted as a diffusion apparatus. This apparatus is suitable for the liberation and recovery of volatile radioactive components which are to be counted by liquid scintillation procedures. The apparatus was adapted to the recovery of $^{14}CO_2$ from aqueous solution, blood suspensions, enzymic incubations, and wet combustions of $^{14}C$-labeled glucose. (auth)

**27315** POLAROGRAPHY OF RADIOACTIVE SUBSTANCES. J. Blazek and D. M. Wagnerova (Inst. for Nuclear Research, Czechoslovak Academy of Sciences, Prague). Collection Czech. Chem. Commun., 29: 915-22(Apr. 1964). (In German)

By use of radioisotopes in polarography the radioisotope separated at a chosen potential on the dropping electrode can be determined radiometrically. This method was tested using the isotopes $^{204}Tl$ and $^{106}Ru$ and their applicabilities were investigated. In the mercury drops $\beta$-irradiators with low radiation energy can also be reliably determined provided changes in the radiation self-absorption in the preparation is eliminated. The determination is not limited only to elements that form amalgams with mercury, but is also applicable if the elements form an insoluble coating on the drop. The dependence of radioactivity measured in the dropped mercury on the dropping time, amount of mercury, specific activity of the solution, and concentration of the nonradioactive carrier were determined. (tr-auth)

**27316** VIII. COLLOQUIUM SPECTROSCOPICUM INTERNATIONALE 14. BIS 18. SEPTEMBER 1959 IN LUZERN. (Eighth International Spectroscopy Colloquium, September 14 to 18, 1959, Lucerne). Colloq. Spectros. Intern. 8th, Lucerne, Switz., 1959, 1-319(1960). Aarau, Switzer-

land and Frankfurt am Main, Verlag H. R. Sauerlander & Co., 1960.

Sixty-eight papers presented at the Eighth International Spectroscopy Colloquium are given. Topics covered include emission spectroscopy, mass spectroscopy, and x-ray fluorescence spectroscopy. Separate abstracts were prepared for 8 papers. (M.C.G.)

*For abstracts of individual papers see: 27317, 27318, 27319, 27320, 27321, 27322, 27323, and 28773.*

**27317** SPECTROSCOPIC DIAGNOSTICS IN THE PHYSICS OF HOT PLASMAS. W. Lochte-Holtgreven (Universität, Kiel). Colloq. Spectros. Intern. 8th, Lucerne, Switz., 1959, 9-14(1960). (In German)

Some methods of spectroscopic research, which were especially successful, are surveyed. While in case of thermal equilibrium the determination of the electron pressure and the temperature of a plasma using Saha's equation is almost a classic process, studies during recent years were mainly concentrated on chemical reactions. Flash photolysis, by which free radicals can be detected in the course of a chemical reaction is one of these methods. The preparation of trapped radicals, a processus of conserving free radicals by freezing in is another technique. When trapped radicals are warmed up, the chemical valences become active and light is emitted, which can be analyzed. Electron attachment was very successfully studied. Big molecules, in the state of negative ions, as well as single atoms, can be analyzed with good precision. Also it is possible to describe quantitatively the effect of fluctuating micro-fields in a plasma on width and displacement of spectral lines. (auth)

**27318** PROBLEMS OF MASS SPECTROSCOPY. Ernst Schumacher (Universität, Zurich). Colloq. Spectros. Intern. 8th, Lucerne, Switz., 1959, 29-39(1960). (In German)

For some mass spectrometers available on the market, some experimental problems are discussed. For quantitative analysis of trace amounts, relatively simple arrangements were found to be quite suitable and using the method of isotopic dilution it was possible to get both sufficient precision and sensitivity up to $10^{-15}$ g in special cases. Mass spectroscopy of fragments, on the other hand, needed more extended electronic installations and ion sources. Possibilities of a combination of mass spectroscopy and gas chromatography or pyrolysis as well as spectroscopy at very low temperatures and ion emission by field excitation are discussed. (auth)

**27319** ELECTRON/ION RECOMBINATION IN Zn, Cd SPARK DISCHARGES. T. Voeroes (Central Research Inst. for Physics, Budapest). Colloq. Spectros. Intern. 8th, Lucerne, Switz., 1959, 54-8(1960).

The effect of afterglow is shown and described in detail in Zn and Cd time-resolved spectra. It appeared from the research that the cause of the light emitted in the afterglow is radiative electron-ion recombination. The appropriate coefficient of recombination was calculated from the data of ion concentration. The results were in good agreement with theoretical values. This agreement was considered to support the quantum mechanical theory of electron-ion recombination. (auth)

**27320** EMISSION SPECTROSCOPY OF RADIOACTIVE ELEMENTS. John G. Conway (Univ. of California, Berkeley). Colloq. Spectros. Intern. 8th, Lucerne, Switz., 1959, 70-3(1960).

Radioactive materials, which are available in limited quantities because of scarcity or radiation safety hazards, are especially suited to spectro-analytical methods. The emission spectra of many radioactive elements, especially the actinide group, are very complex. Several methods were used to overcome this difficulty; among these were higher resolution, physical separation, and chemical separation of the impurity and the matrix. Studies of the distribution and loss of sample during preparation and excitation can be easily made because of the high sensitivity of counting methods. (auth)

**27321** A STUDY OF THE ELECTRODE PROCESSES OCCURRING IN THE SPECTROCHEMICAL ANALYSIS OF URANIUM OXIDES. Slobodan Marinković (Inst. of Nuclear Science "Boris Kidrich," Belgrade). Colloq. Spectros. Intern. 8th, Lucerne, Switz., 1959, 121-6(1960).

Processes taking place in graphite electrodes during spectrochemical analysis of uranium by the Scribner-Mullin method were studied. It was found that during the steady period of the arc burning, certain volatile impurities, if mechanically mixed with the $UO_2$ matrix, vaporize almost completely, but in the case of the mixture $U_3O_8$ + impurities (other conditions being identical) the amount vaporized is only 5 to 15% of the amount originally present. Spectrographic, x-ray, and other examinations of the samples previously ignited in the arc under proper conditions to obtain the necessary matrix transformation, $U_3O_8 \rightarrow UO_2$, indicated that during this transformation impurities enter the crystal lattice of the $UO_2$ formed and thus their easy liberation from the product is prevented. On the basis of this assumption and taking into consideration the experimentally established courses of both electrode temperature and matrix transformations during arcing, the different vaporization of impurities from the two uranium oxide matrices could be explained. (auth)

**27322** APPLICATIONS OF THE FLUORESCENCE EXCITED BY MEANS OF $\beta$ RADIATION TO THE MEASUREMENT OF THE THICKNESS OF DEPOSITS AND TO ANALYSIS. P. Martinelli (Centre d'Etudes Nucleaires, Saclay, France) and G. Seibel. Colloq. Spectros. Intern. 8th, Lucerne, Switz., 1959, 307-13(1960). (In French)

Principles of the method are outlined and the instrumentation used is described. The different types of radiation detectors were subjects of a detailed study. As a source of $\beta$ radiation $^{90}$(Sr + Y) was used as well as $^{147}$Pm. Great care was taken to eliminate back-diffused electrons by deflection by a strong permanent magnet. The method was applied to measurement of the thickness of deposits of Cr, Zn, Sn, Cd, and Cu on iron as well as Zn, Cr, Ag, and Au on copper and the results obtained are discussed. An attempt was made, to use $\beta$-x-ray fluorescence for the analysis of minerals, iron ore, and glass. The method of $\beta$-x-ray fluorescence was compared with normal x-ray fluorescence and possibilities of further development are cited. (auth)

**27323** SMEKAL-RAMAN TYPE MODIFIED X-RAY SCATTERING. K. Das Gupta (Dept. of Physics, Calcutta). Colloq. Spectros. Intern. 8th, Lucerne, Switz., 1959, 314-16 (1960).

The spectroscopic analysis of x-ray beams, scattered from low atomic number elements, carbon, beryllium, and aluminum, by Du Mond, Bearden, Gingrich, Ehrenberg, and others verified the existence of Rayleigh and Compton scattering but could not detect the phenomenon of partial absorption of photons of Smekal-Raman type. With the help of a bent mica (d = 2.554 Å) Cauchois spectrograph (diameter

of the focal circle = 9 in.) and a bent quartz (d = 1.178 Å) spectrograph (diameter of the focal circle = 5.5 in.) and using $K_\alpha$ and $K_\beta$ radiations of copper and molybdenum from scaled-off x-ray tubes with graphite, polystyrene, and beryllium as scattering specimens the modified lines of Smekal-Raman type were observed and registered exactly in the calculated position. (auth)

**27324** ON THE USE OF ALPHA PARTICLES FOR THE DETERMINATION OF OXYGEN AND CARBON. Charles Engelmann. Compt. Rend., 258: 4279-81(Apr. 27, 1964). (In French)

A method of activation analysis of general applicability was developed, using 44-Mev alpha particles from a cyclotron. The sensitivities of the method for oxygen and carbon are better than $10^{-9}$ and $10^{-8}$ g, respectively. (tr-auth)

**27325** PREPARATION OF URANIUM DIOXIDE BY ELECTROCHEMICAL REDUCTION IN CARBONATE SOLUTION AND SUBSEQUENT PRECIPITATION. II. PRECIPITATION OF URANIUM(IV) FROM SODIUM CARBONATE SOLUTIONS. M. Branica, V. Pravdić, and Z. Pučar (Institut "Ruder Bošković," Zagreb). Croat. Chem. Acta, 35: 281-7(1963).

The precipitation of uranium(IV) from sodium carbonate solutions was studied. Uranium(IV) was prepared by electrochemical reduction at controlled constant potential at the mercury cathode. From the stable solution uranium(IV) precipitates as hydrous oxide. The dependence of the degree of precipitation of uranium(IV) on the composition of the solution is given, considering the carbonate to uranium concentration ratio, the total sodium carbonate concentration, and the pH of the solution. The precipitation was induced and performed also by raising the temperature up to 60°C. Experimental limits of the solubility of uranium(IV) carbonate complexes, at 60°C and at pH = 9.5 and 10.3, indicate the possibility of the existence of the uranium(IV) in solution predominantly as the $[U(OH)_2(CO_3)_4]^{-6}$ complex. (auth)

**27326** ON THE GOLD CONTENTS OF ROCKS. A. R. DeGrazia and Larry Haskin (Univ. of Wisconsin, Madison). Geochim. Cosmochim. Acta, 28: 559-64(May 1964).

Forty-one materials were examined for their gold contents by a neutron activation technique. The spread in gold concentrations was found to be relatively narrow, between 0.6 and 44 parts per billion, for the fairly wide variety of samples. A crustal gold abundance of ~2.5 ppb is indicated. (auth)

**27327** THE ALUMINUM CONTENT OF CHONDRITIC METEORITES AS DETERMINED BY ACTIVATION ANALYSIS. David E. Fisher (Cornell Univ., Ithaca, N. Y.). Geochim. Cosmochim. Acta, 28: 743-9(May 1964).

A method is presented for the nondestructive determination of Al in stony meteorites by neutron activation with subsequent gamma counting. Data are reported for ten chondrites. The data indicate little variation in chondritic Al contents, the average value being about 1.33%. (auth)

**27328** DETERMINATION OF STRONTIUM IN SURFACE WATERS BY FLAME PHOTOMETRY. G. M. Svishchev, Yu. M. Nikolaev, N. Ya. Novikova, and M. M. Golutvina. Gigiena i Sanit., No. 4, 65-9(Apr. 1964). (In Russian)

A device is described for determining strontium in surface waters without a preliminary separation from interfering impurities. The device consisted of a sputtering torch, monochromator, photoelectric attachment, d-c amplifier, and microammeter. The exit slit was adjusted to the 460.7 mμ Sr line with a slit opening of 0.08 mm. The mean square error of measurements was ±30% for ≈0.25 γ/ml and 10% for 1 γ/ml. The device is capable of 20 analyses per day. A table of Sr contents in rivers determined by chemical and spectral methods showed almost identical results. (R.V.J.)

**27329** A MICROCHEMICAL METHOD FOR THE DETERMINATION OF STRONTIUM IN SOME PLANT MATERIALS. U. P. S. Chauhan and B. C. Ray Sarkar (Research and Development Organization, Delhi). Indian J. Chem., 2: 175-8(May 1964).

A paper chromatographic method is described for the separation of Sr from Ca and Ba and for the estimation of Sr in some plant materials. Strontium, which separates on chromatography, is estimated by measuring the density of color developed by appropriate treatment with o-cresolphthalein complexone. The Sr content of the eight different plants estimated by this procedure was found to be within 100 μg/g dry matter except in the case of radish leaves, which contain a high amount of Sr (829 μg/g). (auth)

**27330** AMINOPHOSPHONIC ACID MONO-ESTERS AS REAGENTS FOR SOLVENT EXTRACTION OF METALS. V. Jagodić (Ruder Bošković Inst., Zagreb). J. Inorg. Nucl. Chem., 26: 1103-9(June 1964).

N-substituted mono-esters of α-aminophosphonic acid were examined as complexing agents for the extraction of metal from solutions. It was established that N-alkyl substituted derivatives do not form salts or complexes with metals because of a strong betaine like structure. On the contrary, N-aryl substituted derivatives exhibited well pronounced extractive properties. The examination of easy accessible mono-esters of α-anilinobenzylphosphonic acid showed that octyl-α-anilinobenzylphosphonate dissolved in ligroin can be successfully used for extraction of Mn, Co, Ni, Fe, Sb, Bi, and U from aqueous sulfuric acid solutions. The conditions are described in which a separation of Mn from Co or Ni, as well as a Sb separation of Sb (or Bi) from As is quantitatively achieved. Some extractable metal complexes with ethyl- or octyl-α-anilinobenzylphosphonic acid were identified spectrophotometrically or isolated and determined by chemical analysis. (auth)

**27331** EXCHANGE PROPERTIES OF COMPLEX CYANIDES. I. ION EXCHANGE OF CAESIUM ON FERROCYANIDES. V. Kouřím, J. Rais, and B. Million (Nuclear Research Inst., Czechoslovak Academy of Sciences, Rez). J. Inorg. Nucl. Chem., 26: 1111-15(June 1964).

The properties of some heavy metal ferrocyanides are described from the standpoint of their use as ion exchangers for Cs. Among the ferrocyanides studied, the Zn and Cu compounds were found to be the most promising materials for column operation. (auth)

**27332** NEUTRON ACTIVATION PAPER CHROMATOGRAPHIC ANALYSIS OF HUMAN CEREBROSPINAL FLUID. Rolf Blomstrand and Fumio Nakayama (Univ. of Lund, Sweden). J. Neurochem., 8: 230-3(Dec. 1961).

A microtechnique for the determination of the phospholipid components in cerebrospinal fluid is described in which paper chromatography after mild hydrolysis is followed by neutron activation. The method enabled the analyses of phospholipids to be made with considerable reliability. The major phospholipids identified were

lecithin, phosphatidylethanolamine, and sphingomyelin but lysolecithin, phosphoinositide, phosphatidylserine, and choline plasmalogen were also present in small amounts. The possibility of introducing this technique for clinical use is suggested. (P.C.H.)

**27333** REAGENTS AND REACTIONS FOR QUALITATIVE INORGANIC ANALYSIS. Fifth Report. Pure and Appl. Chem., 8: 1-88(1964).

Reagents and reactions for the qualitative determination of inorganic ions are listed. The selection of tests was made on the general basis of selectivity and sensitivity. As far as possible, specific or highly selective reactions were chosen so that the tests could be used directly without recourse to elaborate separation schemes. 80 tests are listed alphabetically. (P.C.H.)

**27334** QUANTITATIVE AUTORADIOGRAPHY FOR PLUTONIUM FUEL ANALYSIS. M. P. Lagache (General Electric Co., Pleasanton, Calif.). Trans. Am. Nucl. Soc., 7: 109(June 1964).

**27335** NEUTRON ACTIVATION ANALYSIS OF ELEMENTS AT CONCENTRATIONS OF LESS THAN 1 PART/$10^9$. Chester E. Gleit (Tracerlab, Inc., Richmond, Calif.), Walter D. Holland, Phillip A. Benson, and Irving J. Russell. Trans. Am. Nucl. Soc., 7: 204(June 1964).

**27336** CAVITATION-DAMAGE MEASUREMENTS IN MERCURY BY RADIOTRACER ANALYSIS. W. Smith, F. G. Hammitt, J. M. Nieto, and M. J. Robinson (Univ. of Michigan, Ann Arbor). Trans. Am. Nucl. Soc., 7: 204-5 (June 1964).

**27337** X RAY SPECTRAL ANALYSIS OF RARE EARTH ELEMENTS. T. V. Ternovaya (Inst. of General and Inorganic Chemistry, Academy of Sciences, Ukrainian SSR). Ukr. Khim. Zh., 29: 205-8(1963). (In Russian)

Results of x-ray spectral analysis of rare earth powders using a single-channel spectrometer showed 3 to 10% relative order of accuracy. Duration of the analysis is 2 to 4 hr. (R.V.J.)

**27338** ACTIVATION ANALYSIS: A NEW STABLE ISOTOPE METHOD FOR TRACER STUDIES. James T. Lowman and William Krivit (Univ. of Minnesota, Minneapolis). Univ. Minn. Med. Bull., 33: 203-13(Feb. 1962).

A tracer method is described that uses stable isotopes which are detected and measured by thermal neutron activation analysis. For this tracer method, the isotopes selected should not occur naturally in the biologic samples; if present, they should occur in minute quantities. To illustrate the technique, in vitro recovery studies of $^{58}Fe$ in human plasma, as well as in vivo plasma clearance rates of simultaneously injected $^{58}Fe$ and $^{59}Fe$, are presented. Samples of plasma containing $^{58}Fe$ were dried on aluminum (99.99% purity) foil and irradiated with a neutron flux of $\sim 1.5 \times 10^{13n}$ per $cm^2$. Calculations pertaining to flux, length of irradiation necessary, and cross-section capture radii are considered. Following irradiation, samples were set aside for 14 days to allow for decay of the short half-life isotopes produced. Samples were then placed in a 400-channel multichannel analyzer with a 5 × 5 in. NaI (thallium-activated) crystal. The counts recorded under the 1.28-Mev peak of $^{59}Fe$ were corrected for decay and multiplied by their respective correction factors. Activation analysis can also be used to measure Na, K, Mg, P, Mn, Cl, and I. However, in biologic specimens in which there are many elements, specific changes in detector arrangements or a radiochemical separation may be necessary to rid the sample of interfering isotopes. In biologic samples the interfering isotopes Na, K, and Cl have relatively short half lives, and by delaying counting a few days, most of the activity from these isotopes is dissipated. Thus, the characteristic peaks of longer half-life isotopes are clearly identified. (BBB)

**27339** DETERMINATION OF RADIO-CERIUM ISOTOPES IN IRRADIATED FUELS. H. H. Stamm (Kernforschungszentrum, Karlsruhe, Ger.). Z. Anal. Chem., 200: 257-65(1964). (KFK-207). (In German)

A method for the separation of cerium from fission products is described. The chemical principles of the method are discussed. Decontamination from a number of fission elements was determined for two separation steps, solvent extraction with methylisobutyl ketone and precipitation of cerium(III)-oxalate. The method was tested by separating fission cerium from an irradiated sample of uranium oxide. (auth)

**27340** THE X-RAY FLUORESCENCE ANALYSIS OF RARE EARTH–MANGANESE ALLOYS. Hans Rodolf Kirchmayr and Dominik Mach (Technische Hochschule, Vienna). Z. Metallk., 55: 247-51(May 1964). (In German)

The composition of rare earth (gadolinium, samarium, yttrium)–manganese alloys may be analyzed exactly by x-ray-fluorescence analysis even if only small samples (0.001 to 0.02 g) are available. The analysis of solid, compressed alloy powders permits small concentrations to be determined (manganese in gadolinium: $1 \times 10^{-3}$ wt % and gadolinium in manganese: $6 \times 10^{-3}$ wt %). Exact analysis ($3\sigma = 0.5$ to 1%) in the range rare earth/manganese = 1/100 to 100/1 had to be carried out in aqueous solutions with the main component removed. The relative concentration difference that could be safety discerned was 0.7%. (auth)

**27341** SPECTROPHOTOMETRIC STUDY OF THE REACTIONS OF CERIUM, LANTHANUM AND YTTRIUM WITH XYLENOL ORANGE. L. S. Serdyuk and V. S. Smirnaya (Dnepropetrovsk State Univ., USSR). Zh. Analit. Khim., 19: 451-6(1964). (In Russian)

The formation of colored Ce, Y, and La complexes with Xylenol Orange was studied by a spectrophotometric method. It was found that the absorption maxima of these complexes are at 570 mμ. It was established by the method of isomolar series that Ce, La, and Y react with Xylenol Orange in the ratio of 1:1. By means of isomolar series curves the instability constants of Ce, La, and Y complexes were found to equal $(4.3 \pm 0.3) \times 10^{-7}$, $(4.1 \pm 0.3) \times 10^{-7}$, and $(3.1 \pm 0.2) \times 10^{-7}$, respectively. It was found that the optical densities of the reagent and the complexes studied differ most at pH 6.0. The reactions with Xylenol Orange can be used for the photometric determination of individual rare earths, as well as the total rare earths of the Ce group. (auth)

**27342** EXTRACTION SEPARATION OF NIOBIUM FROM TANTALUM AND TITANIUM WITH AMMONIUM PYRROLIDINEDITHIOCARBAMINATE. I. M. Gibalo, I. P. Alimarin, and P. Davaadorzh (Moscow State Univ.). Zh. Analit. Khim., 19: 467-9(1964). (In Russian)

The possibility of separating Nb from Ta and Ti by the extraction of Nb pyrrolidinedithiocarbaminate with chloroform in a weakly acid medium at pH 5 and in concentrated hydrochloric acid (9 to 10 N HCl) was studied. It was found that $Nb_2O_5$ can be separated from 1.5 times as much of Ta and from 100 times as much of Ti from 9 N HCl solutions. (auth)

**27343** PHOTOMETRIC DETERMINATION OF ZIRCONIUM IN STEEL AND CAST IRON USING ARSENAZO III. S. B. Savvin, D. S. Kadaner, and A. S. Ryabova (Vernadskii Inst. of Geochemistry and Analytical Chemistry, Moscow and Scientific-Research and Design Technological Inst. of Machine Building, Kramatorka, USSR). Zh. Analit. Khim., 19: 561-3(1964). (In Russian)

A method was developed for the direct determination from 0.01 to 0.5% of zirconium in steel and cast iron using arsenazo III. Common alloy components do not interfere. One determination takes 1–2 hrs. (auth)

**27344** EXTRACTION OF FLUOTANTALATE WITH BASIC DYES. COMMUNICATION 2.A COMPARATIVE STUDY OF CERTAIN BASIC TRIPHENYLMETHANE DYES AS REAGENTS FOR THE EXTRACTION-PHOTOMETRIC DETERMINATION OF TANTALUM. S. V. Makarova and I. P. Alimarin (Moscow State Univ.). Zh. Analit. Khim., 19: 564-8(1964). (In Russian)

The extraction of tantalum as fluotantalate compounds with certain basic triphenylmethane dyes was studied. It was found that the extraction of fluotantalate ions depends on the composition of the dye. A comparative study of a number of dyes as reagents for the extraction-photometric determination of tantalum was carried out, and the effect of Nb, Ti, Zr, and W was considered. Crystal violet, malachite green, and brilliant green are suggested for the determination of tantalum in the presence of large amounts of niobium. The colored extracts should not be exposed to the sunlight, otherwise the color becomes less bright. (auth)

**27345** EXTRACTION-PHOTOMETRIC DETERMINATION OF MOLYBDENUM WITH TIRON. A. I. Busev and G. P. Rudzit (Moscow State Univ.). Zh. Analit. Khim., 19: 569-73(1964). (In Russian)

Extraction of diphenylguanidinium salts of compounds of molybdenum with tiron (disodium salt of pyrocatechol-3,5-disulfonic acid) was studied. The developed extraction-photometric method for molybdenum determination with tiron has certain advantages in comparison with the methods for the determination of molybdenum with the same reagent in a neutral aqueous medium. It permits the determination to be carried out in the presence of iron(III) ions, as a brightly colored compound of iron with tiron remains in the aqueous phase. It is possible to carry out the extraction from an aqueous solution with pH 2.2 and thus eliminate the interference of many ions that are hydrolyzed in a neutral solution. (auth)

**27346** STUDY OF POLAROGRAPHIC BEHAVIOR OF URANYL COMPLEX COMPOUNDS WITH ORGANIC REAGENTS. I. A. Tserkovnitskaya and T. T. Bykhovtseva (Leningrad State Univ.). Zh. Analit. Khim., 19: 574-83 (1964). (In Russian)

The possibility of the amperometric determination of uranium in a medium of non-aqueous solvents was demonstrated by titrating with bromopyrogallol red and arsenazo III solutions. The polarographic determination of uranium is possible as a complex compound of uranium(VI) with benzohydroxamic acid. It permits the separation of uranium from the impurities to be carried out together with its determination without back extraction. (auth)

**27347** ON THORIUM DETERMINATION IN THE TOTAL OF LANTHANIDES OXIDES (POLIRIT) BY A METHOD OF COMPLEXING CHROMATOGRAPHY. D. I. Ryabchikov and M. P. Volynets (Vernadskii Inst. of Geochemistry and Analytical Chemistry, Moscow). Zh. Analit. Khim., 19: 642-3(1964). (In Russian)

In the analysis of polirit by means of radioactive indicators the possibility of complete separation of microgram amounts of thorium from the bulk of the lanthanides by the method of complexing chromatography on a KY-2 cation exchanger was found using diethylenetriaminepentaacetic acid as an eluent. (auth)

**27348** USE OF ION-EXCHANGE CHROMATOGRAPHY FOR THE ANALYSIS OF RHENIUM, RUBIDIUM, AND CESIUM SALTS. M. G. Serdyuk. p.67-9 of "Promyshlennost' Khimicheskikh Reaktivov i Osobo Chistykh Veshchestv." Moscow, 1963.

A method was developed for determining the content of the basic substance in a number of soluble salts of rhenium, rubidium, and cesium using the cation-exchange resin KU-2 in the H-form. The corresponding acid obtained as a result of ion exchange was determined by a volumetric method, permitting a six-fold reduction of analysis time for the salts in comparison with gravimetric methods. It was noted that ion-exchange chromatography can also be used to analyze perchlorates, chlorates, lactates, tartrates, acetates, and other salts, as well as for the purification of water and reagents and the extraction of rare elements from waste products. (OTS)

**27349** I. THE USE OF FLUOBORIC ACID FOR THE DETERMINATION OF RADIOACTIVE CESIUM IN FISSION PRODUCT MIXTURES. II. DETERMINATION OF RADIOACTIVE CESIUM IN MILK. Jack Lamar Johnson. Thesis, Detroit, Wayne State Univ., 1959. 61p.

A procedure was devised for the determination of radioactive cesium in fission product mixtures using fluoboric acid as the precipitating agent. The method was compared with the perchlorate method and it was found that the radiometric yields were comparable but the gravimetric yields were lower. The fluoborate method does not involve maintaining anhydrous conditions and therefore is more rapid than the perchlorate method. The fluoborate method has the disadvantage that plastic centrifuge tubes must be used in precipitating the radiometric material. In the determination of radioactive cesium in milk, it is necessary to eliminate all organic material before an analysis can be made. A study of wet oxidation methods proved unsuccessful since it was difficult to precipitate cesium from the solution remaining after the wet oxidation process. The procedures were long and required the careful attention of the analyst. A study of ion exchange methods showed that a lithium-treated cationic resin column extracted the cesium from milk. A procedure was developed that gave good results for samples of milk up to 200 ml in volume. The procedure is lengthy due to the flow rate of the solutions through resin columns, but the method does not require the careful attention of the analyst as with wet oxidation methods. Larger resin columns were used and a procedure devised for determining the cesium in one quart samples of milk. (Dissertation Abstr., 24: No. 11, 1964)

**27350** TECHNIQUE OF INORGANIC CHEMISTRY. VOLUME I. Hans B. Jonassen and Arnold Weissberger, eds. New York, Interscience Publishers, 1963. 273p. $9.50.

Information is included on: determinations of formation constants of complexes; techniques with nonaqueous solvents; fused salt techniques; spectral measurements in high-pressure systems; use of electrical charges in chemical syntheses; and differential thermal analysis.

The article on fused salt techniques was abstracted separately in NSA. (P.C.H.)

*For abstract of individual chapter see: 27351.*

**27351** FUSED SALT TECHNIQUES. John D. Corbett and Frederick R. Duke (Ames Lab., Ames, Iowa). Chap. 3, p.103-56 of "Technique of Inorganic Chemistry. Vol. I." New York, Interscience Publishers, 1963.

This review on fused salts includes discussion on: general apparatus and methods used in fused salt techniques; preparation and purification of materials; equilibrium properties of fused salts; dynamic properties of fused salts; and spectra and diffraction. 235 references are included. (P.C.H.)

**27352** DETERMINATION OF VERY SMALL AMOUNTS OF SCANDIUM AND COBALT IN S.R. GRADE BERYLLIUM BY NEUTRON ACTIVATION AND GAMMA SPECTROSCOPY. F. Dugain (Compagnie Pechiney, Grenoble, France). 16p. (CONF-524-8)

From American Institute of Mining, Metallurgical and Petroleum Engineers Annual Meeting, New York, Feb. 1964.

A procedure was developed by which Co and Sc quantities as small as $10^{-9}$ and $10^{-10}$ g, respectively, can be accurately determined using neutron activation analysis and radiochemical separations with an irradiation of $2 \times 10^{12}$ neutrons/cm$^2$/sec for 120 hrs. The procedure and typical results are discussed. (D.C.W.)

**27353** METHOD OF SEPARATING RARE-EARTH ELEMENTS. G. V. Korpusov, R. D. Korpusova, A. B. Loginov, and E. N. Patrusheva. Russian Patent 158,419.

A method of separating rare-earth elements by extraction is characterized in that, to produce selective concentration, the extraction is performed in weak acidic or neutral media in the presence of a salting-out agent or a complex-forming agent by means of a mixture of carbonic acids. (OTS)

## Inorganic and Physical Chemistry

**27354** (ASD-TDR-62-204(Pt.III)) THERMODYNAMIC AND KINETIC STUDIES FOR A REFRACTORY MATERIALS PROGRAM. L. A. McClaine, ed. (Little (Arthur D.) Inc., Cambridge, Mass.). Apr. 1964. Contract AF33 (616)-7472. 235p.

Work during 1963 is reported and the work from mid-1960 reviewed on a comprehensive program of thermodynamic and kinetic studies necessary to the theoretical consideration to temperatures of 3000°K of the reactions of the zirconium and hafnium carbides and borides with oxygen- or halogen-containing atmospheres. Work presented includes: preparation of borides and carbides; low temperature heat capacity measurements on $HfB_2$, HfC and hafnium metal; estimation of entropies at 298°K for refractory diborides, nitrides, carbides, and oxides from high temperature heat content data; current status of heats of formation of the borides and carbides from oxygen and fluorine bomb calorimetry; and studies proving feasibility of the "matrix isolation technique" for spectroscopy of high temperature molecules through studies on the lithium halides. Status of electron diffraction, equilibria, and heat of solution studies of the hafnium and zirconium halides is presented. Kinetic studies completed on the oxidation and fluorination of the hafnium and zirconium carbides and diborides are presented in detail. From a-c and d-c electrical conductivity studies on tetragonal $ZrO_2$, a model of the defect structure is devised and oxygen diffusion in $ZrO_2$ is calculated. (auth)

**27355** (CEA-R-2424) CONTRIBUTION A L'ETUDE DE L'OXYDATION DU COBALT ET DE SON PROTOXYDE DANS L'AIR AUX TEMPERATURES ELEVEES. (Contribution to the Study of the Oxidation of Cobalt and Its Protoxide in Air at High Temperatures). Marie-Genevieve Vallee (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucleaires, Saclay). Jan. 20, 1964. 118p.

Thesis submitted to Universite, Paris.

The surface oxidation process of cobalt in air follows a parabolic law and is characterized between 750 and 1350°C by an activation energy of 41,000 cal/mole. Between 400 and 900°C the oxide film is made up of two layers: CoO next to the metal and $Co_3O_4$ on the surface. Above 900°C, only CoO remains. The morphological properties of these films have been studied; growth anisotropy, crystallization facies, oxide grain growth, texture, nucleation of $Co_3O_4$ on a CoO base round about 900°C. The oxidation of cobalt protoxide between 700 and 910°C results in the building up, on the outside surface of CoO discs, of a usually continuous layer of $Co_3O_4$. Under certain conditions this surface reaction is accompanied by a reaction along the longitudinal symmetry plane of the sample where a layer of $Co_3O_4$ of very irregular thickness builds up. (auth)

**27356** (CONF-74-27) MASS-SPECTROMETRIC STUDIES OF GASEOUS INORGANIC FLUORIDES. G. D. Blue, J. W. Green, T. C. Ehlert, and J. L. Margrave (Wisconsin. Univ., Madison). [1963]. Contract AT-11-1-GEN-7. 10p.

From 11th Annual Conference on Mass Spectrometry and Allied Topics, San Francisco, May 1963.

Gaseous mono- and difluorides of four of the alkaline earth metals and of silicon were studied mass spectrometrically and their thermodynamic properties derived from both absolute pressure and temperature dependence measurements. Data for the reduced states were obtained by adding Al or Si to an alkaline earth difluoride and by observing various homogeneous and heterogeneous equilibria. The monofluorides of Mg, Ca, Sr, and Ba were found to be much more stable than was previously supposed and the results tend to support an ionic model for these molecules. The data for the difluorides and SiF are in general agreement with literature values. A heat of formation of gaseous aluminum trifluoride was also obtained. (auth)

**27357** (IS-871) THEORY OF ZEEMAN EFFECT FOR RARE-EARTH IONS IN CRYSTAL FIELD WITH $C_{3h}$ SYMMETRY. T. Murao, F. H. Spedding, and R. H. Good, Jr. (Ames Lab., Ames, Iowa). Apr. 1964. Contract W-7405-eng-82. 130p.

The Zeeman effect for absorption lines of rare-earth ethylsulfates was investigated and explained theoretically. A theoretical investigation of the Zeeman effect was given by Bethe. He considered mostly tetragonal crystals with the applied magnetic field along the tetragonal axis and did not consider in detail the case where the field is applied in a direction perpendicular to the axis. In this case many interesting results are found. It has been found that the electric dipole transition plays the most important role in the absorption lines of rare-earth ethylsulfates, which have $C_{3h}$ symmetry for rare earth ion site, but one cannot completely deny the role of the magnetic dipole

transition. Therefore, both of these transitions are considered. A treatment of eigenstates in a $C_{3h}$ symmetry crystal field is given using an operator method, and the relation of the crystal quantum numbers to the Kramers degeneracy, parity mixing, and selection rules is exhibited. Some useful relations between matrix elements are derived for electric and magnetic dipole moment operators by using the time reversal property of the wave functions. These results are used to calculate general formulas for energy levels and eigenfunctions in a constant magnetic field, and to calculate general formulas for the absorption intensities. The general results obtained are applied to $Tm^{3+}$ and $Er^{3+}$ ions to investigate their absorption lines. A useful theorem on the reality of matrix elements is proven, and some needed degenerate perturbational formulas are derived. (auth)

**27358** (KFK-196) UBER TERNARE OXIDE DES 5- UND 6-WERTIGEN NEPTUNIUMS UND PLUTONIUMS MIT LITHIUM UND NATRIUM. (On the Ternary Oxide of 5- and 6-Valent Neptunium and Plutonium with Lithium and Sodium). Lothar Koch (Kernforschungszentrum. Institut für Radiochemie, Karlsruhe, Germany). Feb. 1964. 74p.

Investigations were made of the oxides of plutonium and neptunium with lithium and sodium. Crystal structure were determined for $Li_4NpO_5$, $Li_4PuO_5$, $Li_6NpO_6$, $Li_6PuO_6$, $Na_2Np_2O_7$, $Na_2NpO_4$, $Na_4UO_5$, $Na_4NpO_5$, $Na_4PuO_5$, $Na_6NpO_6$, and $Na_6PuO_6$. Thermal stabilities of these compounds under oxidizing conditions were studied. (M.C.G.)

**27359** (NP-14035) BIBLIOGRAPHY ON THE HIGH-TEMPERATURE CHEMISTRY AND PHYSICS OF MATERIALS IN THE CONDENSED STATE. Volume 1964, Number 1, January–March 1964. J. J. Diamond, ed. (National Bureau of Standards, Washington, D. C.). 68p.

A total of 711 references is presented on devices for obtaining, measuring, and controlling temperatures above 1500°C; on devices for physical measurements at temperatures above 1000°C; on properties, at temperatures below and above 1000°C, of materials which melt above and below 1500°C; on phase equilibria; and on reactions at temperatures above 1000°C. (D.L.C.)

**27360** (TID-19978(Vol.II)) SURVEY OF ELECTROCHEMICAL TECHNOLOGY APPLICABLE TO WATER ELECTROLYSIS. R. A. Foust, Jr. (General Motors Corp. Allison Div., Indianapolis). Mar. 1964. Contract AT(30-1)-3101. 186p. (EDR-3687(Vol.II))

A survey of electrochemical technology was conducted to provide a basis for the development of the Energy Depot water electrolysis unit with low weight and high energy efficiency. In a brief treatment of electrochemical theory, a comparison is made between electrolysis cell and fuel cell operation. It is shown that electrocatalysts and large electrode constructions will have to be developed for the Energy Depot unit. Catalyst life, electrolyte, temperature, gas bubbles, pressurized operation, and a-c ripple are discussed. (D.L.C.)

**27361** (Y-1470-F) X-RAY FLUORESCENCE TABLES: MICA-48 CRYSTAL. W. P. Amsbury, W. W. Lee, J. H. Rowan, and G. E. Walden (Union Carbide Corp. Nuclear Div. Y-12 Plant, Oak Ridge, Tenn.). Apr. 24, 1964. Contract W-7405-eng-26. 191p.

A critical compilation of standard reference tables of x-ray fluorescence lines is published in convenient form for experimental use. This section of the report contains tables calculated for a mica-48 crystal. (auth)

**27362** (KFK-tr-150) UBER EINIGE GESETZMÄSSIGKEITEN DER KOMPLEX-BILDUNG VON FUNFWERTIGEN ACTINIDEN. (On a Principle of Complexing of Actinides(V)). A. I. Moskvin, I. Geletseanu, and A. V. Lapitskii. Translated into German by Peter Buriks (Kernforschungszentrum, Karlsruhe, Ger.), from Dokl. Akad. Nauk SSSR, 149: 611-14(1963). 18p.

Complex formation by pentavalent actinides (Pa, Np, and Pu) was studied. Composition and stability constants for complexes of these metals with various anions are given in tabular form. The tendency to complex formation with Pa, Np, and Pu varied according to the following sequence: $EDTA^{4-}$ > $citrate^{3-}$ > $HPO_4^{2-}$ > $tartrate^{2-}$ > $acetate^{-}$ ≈ $lactate^{-}$. Calculations for pentavalent complexes of uranium were made on the basis of the data presented. (M.C.G.)

**27363** THE CRYSTAL STRUCTURE OF URANIUM(IV) ACETATE. I. Jelenić, D. Grdenić, and A. Bezjak (Rudjer Bošković Inst., Zagreb). Acta Cryst., 17: 758-9(June 10, 1964).

Crystal structure results on uranium(IV) acetate were obtained from two-dimensional Fourier syntheses evaluated from hk0, hk1, and h0l reflection intensity data. The inconvenient form and size of the crystal specimen of uranium(IV) acetate made collection of accurate intensity data difficult. The large diffraction effect prevented the determination of interatomic distances in the surroundings of the uranium atom with an accuracy any better than ±0.05 Å. No pyroelectric effect was observed. The structure is built up of infinite columns parallel to the c-axis direction in which each acetate ion belongs to two uranium ions. Acetate-ion bridges are situated obliquely to the c-axis direction. The polymeric structure explains the form of the crystals, their fibrous appearance, and the cleavage in the planes parallel to the c axis, as well as their low solubility in all common solvents. Data are tabulated. (P.C.H.)

**27364** THE THORITE — HUTTONITE PHASE TRANSFORMATION AS DETERMINED BY GROWTH OF SYNTHETIC THORITE AND HUTTONITE SINGLE CRYSTALS. C. B. Finch, L. A. Harris, and G. W. Clark (Oak Ridge National Lab., Tenn.). Am. Mineralogist, 49: 782-5(May-June 1964).

The phase transformation, tetragonal $ThSiO_4$ (thorite) — monoclinic $ThSiO_4$ (huttonite), was studied using solution growth of the preferred modification of $ThSiO_4$ single crystals as a criterion for phase stability at a given temperature. Experiments designed to growth $ThSiO_4$ from alkali ditungstate or dimolybdate solutions revealed that only thorite could be grown below 1225 ± 10°C, whereas above this temperature only huttonite could be grown. The synthetic thorite crystals had a growth habit typical of zircon with well-developed prism and dipyramid forms. The growth habit of synthetic huttonite resembled monazite with {100} faces well developed. (auth)

**27365** STUDIES ON THE HEATS OF FORMATION OF STRONTIUM FERRITES. Franco Massazza and Raffaella Fadda (Università, Cagliari, Italy). Ann. Chim. (Rome), 54: 95-102(Jan.-Feb. 1964). (In Italian)

The heats of solution in 4.00N HCl were measured for $3SrO \cdot Fe_2O_3$, $2SrO \cdot Fe_2O_3$, and $\overline{7}SrO \cdot 5Fe_2O_3$. Mixtures of $Fe_2O_3$ and $SrCO_3$ were ground together, pressed 72 hr at 1000°C, sintered, and pressed again for 48 hr at 1250°C and cooled slowly, with special precautions in respective cases. The measurements were made in a Dewar immersed in a water bath thermostated at 25 ± 0.1°C, containing 533.5 g

4.00N HCl. The heats of solution and heats of dilution thus found were: $3SrO \cdot Fe_2O_3$, 133.1 ± 0.3 kcal/mole, 1.5 ± 0.3; $2SrO \cdot Fe_2O_3$, 107.95 ± 0.5, 1.5 ± 0.4; $7SrO \cdot 5Fe_2O_3$, 91.2 ± 0.2, 1.4 ± 0.3. These data combined with others previously determined allow the enthalpies of formation of the ferrites from the oxides and from the elements to be calculated; these values are, respectively, as follows: $3SrO \cdot Fe_2O_3$, −64.8 kcal/mole, −694.5; $2SrO \cdot Fe_2O_3$, −30.9, −516.2; $7SrO \cdot 5Fe_2O_3$, −12.5, −410.9; all at 25°C. By extrapolation of data the heat of formation of $SrO \cdot 6Fe_2O_3$, which is insoluble, was estimated to be 18 kcal/mole. The stability of these ferrites was also examined; ΔF of formation at 25°C from the oxides was estimated as −33.9 kcal/mole for $3SrO \cdot Fe_2O_3$, +1.0 kcal/mole for $2SrO \cdot Fe_2O_3$, +9.7 kcal/mole for $7SrO \cdot 5Fe_2O_3$, and −9.3 kcal/mole for $SrO \cdot 6Fe_2O_3$. Thus the first and fourth are stable. (BBB)

**27366** INVESTIGATION OF COLORED COMPOUNDS OF CERTAIN RARE ELEMENTS WITH ORGANIC REAGENTS. M. K. Akhmedli, A. A. Sadykhova, P. V. Granovskaya, I. S. Lozovskaya, and S. Alieva. Az. Khim. Zh., No. 5, 93-104(1963).

The formation of colored compounds of rare elements ($Be^{2+}$, $Pr^{3+}$, $Gd^{3+}$, $La^{3+}$, $Nd^{3+}$, $Yb^{3+}$, $Y^{3+}$, $Th^{4+}$, $UO_2^{2+}$, and $Ce^{3+}$) with organic reagents (Quinalizarin, alpha-nitroso-beta-naphthol, morin, hematoxylin, juglone, stibazo, acid chrome dark blue, methylene blue, beta-naphthol, Titanium yellow, Congo red, quinone, resorcinol, magneson IREA, phenylfluorone, anthrazo, alizarin yellow, alpha-naphthylamine, and aluminon) was studied. A number of organic reagents forming colored compounds with the cations studied at definite pH values were discovered. Certain of the compounds obtained (yttrium with juglone and morin, beryllium with acid chrome dark blue, and ytterbium with quinizarin) were subjected to photometric investigation, determining $\lambda_{opt}$ and $pH_{opt}$, and the stability of these compounds in time was studied. The concentration limits in which they obey the Bouguer-Lambert-Beer law are presented for the indicated compounds. (OTS)

**27367** INVESTIGATIONS FOR CALCULATION OF KINETIC ISOTOPE EFFECTS. III. USE OF THE FG MATRIX METHOD ON TRANSITION STATES OF $S_N1$ SOLVOLYSIS OF METHYL IODIDE IN WATER. A. V. Willi (Universität, Bern). Ber. Bunsenges, Physik. Chem., 68: 266-9(1964). (In German)

The kinetic D isotope effect for $S_N1$ solvolysis of methyl iodide ($CH_3I$ vs. $CD_3I$) was calculated theoretically. Vibration frequencies of the transition state were obtained by solving the secular equation with an electronic digital computer. The transition state was represented by two different models: Model 1 was identical with the ion pair $CH_3^+I^-$ and model 2 possessed the structure $H_2O\cdots CH_3\cdots I$. A result was calculated for model 2, which agreed well with experimental data. (auth)

**27368** ABSORPTION OF CONGO RED AND FUCHSINE BASE BY HYDROUS BERYLLIUM OXIDE AGED FOR DIFFERENT PERIODS. Rup Dutta (Univ. of Allahabad, India). Bull. Chem. Soc. Japan, 37: 445-6(Apr. 1964).

Three samples of hydrous Be oxide, of different character, were prepared by adding different quantities of an alkali to a fixed volume of Be sulfate solution for precipitation. The samples were allowed to age progressively and their adsorptive capacities for dyestuffs were studied. It was found that the adsorptive capacity of the samples decreases with aging of the hydroxide and the adsorption data dyestuffs reveal that the three samples possess different adsorptive capacities. (auth)

**27369** THE ISOTOPIC HYDROGEN EXCHANGE BETWEEN PROPENE AND DEUTERIUM OXIDE CATALYZED BY NICKEL POWDER. Kozo Hirota and Yoshie Hironaka (Osaka Univ.). Bull. Chem. Soc. Japan, 37: 535-42(Apr. 1964).

The exchange reaction of propene with $D_2O$ by the use of nickel catalysts, supported and unsupported, is described. Deuterium exchange between propene and deuterium oxide was found to occur at room temperature successively on a Ni catalyst, but about six times more easily at the vinyl H than at the methyl H at room temperature, although this finding is not concordant with the expectation derived from the scission energy of the bonds concerned and although it is also different from the easier exchangeability of the methyl H in the similar exchange reaction of p-xylene. The discrepancy is explained by assuming the classical chemisorbed species of propene as an intermediate, i.e., a state of propene that forms bonds between Ni atoms and the C=C group, besides the formation of adsorbed allyl type species on Ni. (P.C.H.)

**27370** RADIOCHEMICAL STUDY OF THE ISOTOPIC EXCHANGE Ca AND P OF A SYNTHETIC SOLID SOLUTION EQUIVALENT TO TRICALCIUM PHOSPHATE HYDRATE. M. Guillaume (Universite, Liege). Bull. Soc. Roy. Sci. Liege, 33: 92-111(1964). (In French)

A solid solution composed of $Ca_4H(PO_4)_3$ and $Ca_{10}(PO_4)_6(OH)_2$ was previously found to have hydrolysis properties identical to those of tricalcium phosphate hydrate. A study of the isotopic exchange of Ca and P with the solid solution further established the structural identity of the solid solution and the tricalcium phosphate hydrate. An attempt was made to analyze the various processes contributing to the total exchange and to evaluate their relative importance. (D.C.W.)

**27371** ELECTRODE POTENTIALS OF THORIUM TETRACHLORIDE IN ALKALI CHLORIDE MELTS. R. Srinivasan and S. N. Flengas (Univ. of Toronto). Can. J. Chem., 42: 1315-22(June 1964).

The electrode potentials of the system Th, $ThCl_4$ (KCl, NaCl) were measured at various concentrations of thorium chloride, and at temperatures between 670 and 850°C, using a silver–silver chloride reference electrode. It was shown by a direct gravimetric method that the reaction, $Th_{(metal)} + ThCl_{4(melt)} = 2ThCl_{2(in\ melt)}$, postulated by others, did not take place. The activity coefficients, and the other partial molal properties of the solutions of $ThCl_4$ in the equimolar mixture of potassium and sodium chlorides, were calculated as a function of temperature from the emf measurements. (auth)

**27372** THE SYNTHESIS OF ANHYDROUS ZIRCONIUM TRICHLORIDE. B. Swaroop and S. N. Flengas (Univ. of Toronto). Can. J. Chem., 42: 1495-8(June 1964).

Zirconium trichloride of a purity over 98 wt % was produced by the direct reaction between finely divided zirconium metal and zirconium tetrachloride at atmospheric pressure. The method, although essentially a batch process, could be adopted for preparation of larger quantities of the compound, if required. (P.C.H.)

**27373** THE INTERACTIONS OF NITROGEN AND CARBON MONOXIDE ON POLYCRYSTALLINE TUNGSTEN. L. J. Rigby (National Research Council, Ottawa). Can. J. Phys., 42: 1256-69(June 1964). (NRC-7920)

Desorption spectra from a polycrystalline tungsten wire were obtained with a mass spectrometer to study the effect of preadsorbed nitrogen on the adsorption of

carbon monoxide, the reversibility and rearrangement of the carbon monoxide monolayer, and the slow replacement of carbon monoxide by nitrogen. Surface coverages were measured, and the activation energies of desorption were obtained for all phases of carbon monoxide and the $\beta$ phase of nitrogen. (auth)

**27374** THE NOBLE GAS COMPOUNDS. Cedric L. Chernick (Argonne National Lab., Ill.). Chemistry, 37: 6-12(Jan. 1964).

The history and developments in the synthesis of rare gas compounds are reviewed. The nature of bonding is also discussed. (P.C.H.)

**27375** POLAROGRAPHIC STUDIES OF THE COMPLEXES OF URANIUM WITH SULFOSALICYLIC ACID. J. Hala (Purkyne Universität, Brno). Collection Czech. Chem. Commun., 29: 905-14(Apr. 1964). (In German)

A graphical and mathematical method is described with which the complex formation constants for stepwise complex formation can be determined from polarographic data for the case in which the central atom is reduced to a lower valence state, which also forms a complex with the ligand concerned. With the help of this method the complexes formed between $UO_2^{2+}$ and $UO_2^{+}$ ions and sulfosalicylic acid were studied. For pH < 6 the complex was $UO_2R^-$ ($\log \beta_1 = 11.65 \pm 0.20$); for pH > 7 the complex $UO_2R_2^{4-}$ was identified ($\log \beta_2 = 17.64 \pm 0.15$). The composition of these complexes could also be confirmed by electrophoretic experiments. In alkaline medium the complex of pentavalent uranium, $UO_2R^{2-}$ ($\log \beta_1 = 5.14 \pm 0.22$) was also polarographically identified. (tr-auth)

**27376** STUDY OF THE THERMAL DECOMPOSITION OF URANYL CHLORIDE MONOHYDRATE. Jacques Prigent and Michel Gueguin (Faculte des Sciences, Rennes, France). Compt. Rend., 258: 4069-71(Apr. 20, 1964). (In French)

The thermal decomposition of uranyl chloride mononydrate was studied under vacuum or in gaseous $N_2$, $O_2$, $Cl_2$, or HCl. (auth)

**27377** ELECTRIC CONDUCTIVITY OF URANIUM OXIDES AT HIGH TEMPERATURE: RELATION WITH THE PARTIAL EQUILIBRIUM PRESSURES OF OXYGEN AND THE CHEMICAL COMPOSITION. Alain Duquesnoy and Fernand Marion (Faculte des Sciences, Lille, France and C. S. U., Amines, France). Compt. Rend., 258: 4072-5(Apr. 20, 1964). (In French)

The variations of the electric conductivity of $UO_{2+x}$ and $U_3O_8$ as a function of the partial equilibrium pressure of oxygen were studied between 800 and 1200°C. (tr-auth)

**27378** THE REACTION OF PURE OXYGEN ON MASSIVE URANIUM MONOCARBIDE. Jean Besson, Claude Moreau, and Joseph Philippot (Centre d'Études Nucléaires, Grenoble, France). Compt. Rend., 258: 4079-82(Apr. 20, 1964). (In French)

The complete oxidation of small parallelepipeds of UC prepared by arc fusion was studied between 550 and 800°C under a pressure of 100 mm of Hg. An oxide ($U_3O_8$) was formed in which the O/U ratio decreased with increasing temperature. Some free, residual carbon was always present. The kinetics of oxidation was always linear with an activation energy of 21.7 ± 1 kcal/mole. A relation between the speed of the reaction and the gas pressure was obtained. (D.C.W.)

**27379** THE STOICHIOMETRY OF $UO_{2+x}$ AND DETERMINATION OF THE $U_4O_9 \rightleftharpoons U_4O_9$ EQUILIBRIUM. Alain Dequesnoy and Fernand Marion (Faculté des Sciences, Lille, France and CSU, Amiens, France). Compt. Rend., 258: 4550-2(May 4, 1964). (In French)

The isothermal variation of the oxygen excess (x) as a function of the equilibrium oxygen pressure was determined by measurements of the electric resistance of oxide films. For a wide range of x values at 900 to 1200°, $UO_{2+x}$ can be considered as an ideal solid solution of $U_4O_9$ and $U_4O_9$. In these composition limits, the isothermal curves $P_{O_2} = f(x)$ are of the form $x^2/(1-4x)^2$. A relation for the equilibrium constant as a function of temperature was also obtained. (D.C.W.)

**27380** HEATS OF IMMERSION OF URANIUM OXIDES IN WATER. II. ANNEALING EXPERIMENTS. D. Kolar (Nuclear Institute "Jozef Stefan," Ljubljana, Yugoslavia). Croat. Chem. Acta, 35: 289-93(1963).

Heats of immersion of original and annealed uranium oxide samples in water were measured. Whereas the unannealed samples gave values in accordance with the already reported results, the values of annealed samples were lower. The structures were determined by the x-ray technique, and the wetting behavior is discussed on the basis of the present knowledge of uranium oxides. (auth)

**27381** AN X-RAY AND PROTON MAGNETIC RESONANCE STUDY OF THE DEHYDRATION AND DEUTERATION OF BORAX, $Na_2[B_4O_5(OH)_4] \cdot 8\,H_2O$. A. Bezjak, I. Jelenic, S. Maricic, and Z. Meic (Institut "Rudjer Boskovic," Zagreb). Croat. Chem. Acta, 35: 259-303 (1963).

A quantitative powder-x-ray analysis was developed for this case by which it was shown that carefully prepared borax dehydrates directly into an unhydrous amorphous phase. Eight molecules of water are quantitatively lost on complete dehydration (below 50°C) as required by the structural formula. The proton magnetic resonance results agree with these findings showing also that the spectrum due to OH-groups changes considerably on dehydration. This was used in following deuteration (solid/gas) of dehydrated borax. The PMR spectra, the x-ray diagrams, and the measured regain indicate a reconstitution of the borax-lattice towards the formula $Na_2[B_4O_5(OH)_4] \cdot 8D_2O$. (auth)

**27382** ULTRASONIC STUDIES IN AQUEOUS SOLUTIONS OF URANYL NITRATE. M. G. Seshagiri Rao and B. Ramachandra Rao (Andhra Univ., Waltair, India). Current Sci. (India), 31: 9-10(Jan. 1962).

Electrolyte solutions, in general, exhibit an increase of ultrasonic velocity with concentration. However, uranyl nitrate solutions showed a decrease of ultrasonic velocity with increasing concentration. All other properties, such as adiabatic compressibility, molar sound velocity, varied as expected. A double-crystal, fixed-path, variable-frequency interferometer was used for the measurement of ultrasonic velocity at 32°C. The ultrasonic velocity decreased with an increase of concentration (76 m/sec for a concentration of 2 moles/l), while the density steadily increased and the compressibility steadily decreased. The slope of the curve representing apparent molal compressibility vs square-root of concentration should be $32.6 \times 10^{10}$ cgs units as calculated from Gucker's limiting equation, as uranyl nitrate is a (2-1) type of electrolyte. The experimental slope was, however, $55 \times 10^{10}$ cgs units, which is far from the theoretical value. The decrease of velocity in

uranyl nitrate solution is in conformity with other observations, namely that electrolytes with heavy acid or metallic radicals produce decreases in velocity with increasing concentration. (BBB)

**27383** TWELFTH SPIERS MEMORIAL LECTURE—DETERMINATION OF THE STRUCTURES OF SIMPLE POLYATOMIC MOLECULES AND RADICALS IN ELECTRONICALLY EXCITED STATES. G. Herzberg (National Research Council, Ottawa). Discussions Faraday Soc., No. 35, 7-29(1963).

Results obtained in the last 10 to 15 years in the study of the structure of polyatomic molecules in their excited states are summarized. Simple allowed electronic transitions are discussed. Complications of the spectrum by change of shape of the molecule are considered from the point of view of both the vibrational and the rotational structure. Vibronic interactions in degenerate electronic states and spin-orbit interactions are described. (M.J.T.)

**27384** ANGULAR CORRELATION DIAGRAMS FOR $AH_2$-TYPE MOLECULES. C. A. Coulson and A. H. Neilson (Oxford Univ.). Discussions Faraday Soc., No. 35, 71-6 (1963).

A study is made of the theoretical basis of Walsh's rules for discussing the equilibrium shapes of polyatomic molecules in ground and excited states. The particular series $AH_2$ is considered, and detailed numerical calculations are made for $H_2O$. It is shown that the use of ionization potentials in Walsh's correlation diagrams may lead to erroneous conclusions, and the importance of the nuclear repulsion energy is emphasized. A scheme of partitioning the total electronic energy in such a way that the total energy is additive with respect to certain defined orbital energies is described and illustrated. (auth)

**27385** ELECTRONICALLY EXCITED STATES OF AMMONIA. A. E. Douglas (National Research Council, Ottawa). Discussions Faraday Soc., No. 35, 158-74(1963).

The ultraviolet absorption bands of $^{14}NH_3$, $^{14}ND_3$, and $^{15}NH_3$, which lie between 1400 and 2200 Å, were photographed at high dispersion, and the rotation structures of a number of the bands were analyzed. The Zeeman effect was studied for a number of the bands. It is shown that in the lowest excited state, which is of $A_2''$ symmetry, the molecule is planar with a bond distance of 1.08 Å. The Zeeman studies show the second excited state to be degenerate. A third excited state which is the upper state of parallel bands near 1500 Å is not fully understood. The electronic states and predissociations of $NH_3$ are discussed. (auth)

**27386** IONIZATION AND DISSOCIATION ENERGIES OF THE HYDRIDES AND FLUORIDES OF THE FIRST ROW ELEMENTS IN RELATION TO THEIR ELECTRONIC STRUCTURES. W. C. Price, T. R. Passmore, and D. M. Roessler (King's Coll., London). Discussions Faraday Soc., No. 35, 201-11(1963).

Curves of the bond dissociation energies of the hydrides and fluorides of the first row elements are given together with the curves for the corresponding processes in the isoelectronic ions. These show the dependence of the energies on the closed shell configurations appropriate to the shape of the radical or ion. When the closed shells are exceeded, stabilization of triatomic species is achieved by bending, while planar tetratomic ones become pyramidal. The curves are also used to obtain the proton affinities of $H_2O$ and $NH_3$. (auth)

**27387** EXPERIMENTAL STUDY OF THE VISCOSITY OF HELIUM AND NITROGEN. R. A. Makavetskas, V. N. Popov, and N. V. Tsederberg (Moscow Energy Inst.). High Temp., 1: 169-75(Sept.-Oct. 1963). (Translated from Teplofiz. Vysokikh Temp., 1: 191-7(Sept.-Oct. 1963)).

The coefficient of dynamic viscosity of He and Ni, and their mixtures at temperatures of 10 to 660°C under pressures of 1 to 600 kg(force)/cm$^2$ were measured by the capillary method with a ring balance apparatus. The apparatus consisted of a gas thermocompressor with a gas analyzer for determining the composition of the gas mixtures. Data are tabulated. (P.C.H.)

**27388** REACTION DIFFUSION IN THE MOLYBDENUM–BERYLLIUM SYSTEM. N. N. Matyushenko. Izv. Akad. Nauk SSSR, Met. i Gorn. Delo, No. 2, 167-71(Mar.-Apr. 1964).

An attempt was made to verify a hypothesis concerning the processes taking place in the course of diffusion annealing of molybdenum in beryllium vapors. It was found that the beryllide phases on molybdenum form as layers arranged in the order of lower to higher beryllides. The chief constituent of the diffusion layer associated with prolonged berylliding of molybdenum is the phase $MoBe_{22}$. In the Mo–Be system, the diffusion of beryllium through the beryllide layers predominates. (OTS)

**27389** NEUTRONOGRAPHIC INVESTIGATION OF CERTAIN COMPOUNDS HAVING A STRUCTURE SIMILAR TO THAT OF PEROVSKITE. V. P. Plakhtii, E. I. Mal'tsev, and D. M. Kaminker. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 436-9(Mar. 1964). (In Russian)

Neutron diffraction was chosen as a suitable method for investigating materials such as $BiFeO_3$ and $PbFe_{\frac{1}{2}}W_{\frac{1}{2}}O_3$, which possess ferroelectric and antiferromagnetic properties. The neutronographic study of $BiFeO_3$ was undertaken primarily to clarify its crystal structure, assuming that the neutron diffraction method, involving all the atoms, will supplement the data obtained by x-ray diffraction in which the effect of the heavy elements, Fe and Bi, predominate. The measurements were carried out on powdered samples, placed in 0.1-mm wall thickness Al containers, at 600°C and at room temperature. The neutronograms were identified on the basis of the doubling of the perovskite unit cell. Beyond the Néel point several peaks were noted; they seemed to indicate that the $BiFeO_3$ has a complex unit cell. The proposed model, derived from experimental data is shown graphically; it allows weak ferromagnetic properties. In the case of the $PbFe_{\frac{1}{2}}W_{\frac{1}{2}}O_3$ an attempt was made to determine the magnetic ordering process and the magnetization of the substructure. Neutronograms were taken both above and below the Néel point (90°C). Three peaks were noted in the range from 17 to 21°C; they are probably due to pyrochloride impurities. Below the Néel point two additional peaks were found; they indicate that this compound is of the G type. (TTT)

**27390** NEUTRONOGRAPHIC STUDY OF $\alpha$-$Fe_2O_3$ TYPE OXIDES. D. Shirane (Brookhaven National Lab., Upton, N. Y.). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 446 (Mar. 1964). (In Russian)

The structure of $Fe_2O_3$ may be considered as if it consists of Fe layers in the rhombohedric (111) plane and of separate O layers. In the case of $Fe_2O_3$ the spin interaction in this plane results in the creation of ferromagnetic properties; on the other hand, in the case $\delta f$ $Cr_2O_3$, these spins are oriented in an antiparallel manner. Previous studies indicated that if the composition is changed, these two types merge continuously into each other, forming ultimately a spiral structure. The magnetic structure of $Cr_2O_3$ may be divided into 2 sublattices having ferromag-

netic interaction at the boundary and antiferromagnetic interaction between the sublattices themselves. Addition of $Fe_2O_3$ results in the formation of a cone-shaped spiral structure in each sublattice. This problem was studied by examining the nature of the magnetic moment of $Fe_2O_3$ by means of a polarized beam. The high sensitivity of this method is due to the coherent character of the magnetic and nuclear scattering, which allows observations of an unpaired electron that controls the formation of the magnetizability component, responsible for the weak ferromagnetism. (TTT)

**27391** ANISOTROPY OF THE RESONANCE CURVE WIDTH IN YTTRIUM GARNET CONTAINING RARE-EARTH ADMIXTURES. A. G. Gurevich, Ts'ien-chen Mêng, S. S. Starobinets, V. I. Solovev, and I. E. Myl'nikova. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 462-9(Mar. 1964).

Perfect Y garnet single crystals represent an ideal medium for studying ferromagnetic resonance phenomena, especially the anisotropy and relaxation due to rare-earth admixtures. Experiments were therefore carried out on single crystals grown from molten mixtures, using Y oxide with a purity of 99.9995% and rare earths with a purity better than 99.99%. After polishing, the width of the resonance curve of the garnet specimens without admixtures was not more than 3 oersted. The spherical specimens were placed in a rectangular resonator and the measurements made at 4.2 to 78°K by immersion in liquid He. At temperatures exceeding the "abnormal" maxima, angular minima were observed in Y garnets containing rare-earth admixtures at angles at which the energy levels of the rare-earth ions converge. The low-temperature angular maxima of these garnets possessed a fine structure. It was also found that the anisotropy of the resonance curve of the spin waves attributable to the rare-earth admixtures does not depend markedly on the wave number. The anisotropy effect was characteristic for the ion involved and its magnitude exceeded that of the similar effect due to high temperatures. (TTT)

**27392** INFRARED ABSORPTION SPECTRA OF THORIUM(IV) COMPLEXES WITH NCS GROUPS. Yu. Ya. Kharitonov, A. K. Molodkin, and A. V. Babaeva (Kurnakov Inst. of General and Inorganic Chemistry, Academy of Sciences, USSR). Izv. Akad. Nauk SSSR, Ser. Khim., No. 4, 618-22(Apr. 1964). (In Russian)

An attempt was made to determine which of the atoms (nitrogen or sulfur) causes the NCS group to coordinate in thorium(IV) complexes: $M_4Th(NCS)_8 \cdot 2H_2O$ (where M = $NH_4$, Rb, and Cs), $K_4Th(NCS)_8 \cdot 3.5H_2O$ $(NH_4)_3Th(NCS)_7 \cdot 5\ H_2O$, $RbTh(NCS)_5 \cdot 3H_2O$, and $Th(NCS)_4 \cdot 4H_2O$. In the above complexes the NCS group coordinates through the nitrogen atom. (R.V.J.)

**27393** ELECTRON PARAMAGNETIC RESONANCE AND NUCLEAR SPIN ECHO IN PENTAVALENT MOLYBDENUM OXYFLUORIDES. N. S. Garif'yanov, V. N. Fedotov, and N. S. Kucheryavenko (Inst. of Physics and Tech., Academy of Sciences, Kazan, USSR). Izv. Akad. Nauk SSSR, Ser. Khim., No. 4, 743-5(Apr. 1964). (In Russian)

The electron paramagnetic resonance and nuclear spin echo in liquid and supercooled $K_2[MoOF_5]$, $(NH_4)_2[MoOF_5]$, $Zn[MoOF_5]$, and $Cu[MoOF_5]$ solutions were studied at 295, 213, and 77° (with ~0.01 m/l Mo(V) concentration and 30% hydrofluoric acid). Acid solutions of $(NH_4)_2[MoOF_5]$, $Zn[MoOF_5]$, $K_2[MoOF_5]$, and $Cu[MoOF_5]$ dissociate into the complex anion $[MoOF_5]$ and the cations $K^+$, $Zn^{2+}$, $(NH_4)^+$, and $Cu^{2+}$. The covalent $^{19}F$ bonding with the complexing agent formed, in the complex $(MoOF_5)^{2-}$ anion, an ultra hyperfine structure from four $^{19}F$ nuclei. The long-life of $^{19}F$ in the complex reduces the effectiveness of Mo(V) on the $^{19}F$ nuclear relaxation; at elevated temperature the life of $^{19}F$ becomes shorter and with it effectiveness of Mo increases. In the complex $[MoOF_5]^{2-}$ the magnetic ion Mo(V) is in an octahedron form by five covalent atoms: four fluorides and one oxygen. The fifth fluorine atom is in transposition to oxygen and bound by an ionic valence. (R.V.J.)

**27394** RAMAN SPECTRUM OF XENIC ACID. Howard H. Claassen and Geraldine Knapp (Argonne National Lab., Ill.). J. Am. Chem. Soc., 86: 2341-2(June 20, 1964).

The Raman spectrum of a 2.0M aqueous solution of $XeO_3$ was obtained. Intense bands at 780, 344, 833, and 317 $cm^{-1}$ were assigned as $\nu_1$, $\nu_2$, $\nu_3$, and $\nu_4$, respectively, of unionized $XeO_3$ molecules of symmetry $C_{3v}$. Several much weaker bands were assigned to a low concentration of an unknown species. (auth)

**27395** THE CHEMISTRY OF THE NOBLE GASES. Herbert H. Hyman (Argonne National Lab., Ill.). J. Chem. Educ., 41: 174-82(Apr. 1964).

The chemistry of the rare gases is discussed, along with theoretical approaches currently used to explain chemical bond formation, and the course of developments in rare gas chemistry are reviewed for the year 1963. (P.C.H.)

**27396** RAMAN SPECTRAL STUDIES OF WATER STRUCTURE. G. E. Walrafen (Bell Telephone Lab., Inc., Murray Hill, N. J.). J. Chem. Phys., 40: 3249-56(June 1, 1964).

The Raman frequencies and polarizations and infrared frequencies of water and heavy water were obtained, and the intermolecular vibrations of water were related to a five-molecule hydrogen-bonded $C_{2v}$ model consistent with x-ray data. The observed variations of the integrated Raman intensity of the 175-$cm^{-1}$ hydrogen-bond-stretching vibration, with variations of temperature, were interpreted in terms of a five-molecule model, leading to reasonable values for the enthalpy of hydrogen-bond formation. Effects of electrolyte addition on the intensity of the 175-$cm^{-1}$ band are also described. (auth)

**27397** MICROWAVE SPECTRUM OF $NO_2$: FINE STRUCTURE AND MAGNETIC COUPLING. George R. Bird (Polaroid Corp., Cambridge, Mass.), James C. Baird, Albert W. Jache, Jimmie A. Hodgeson, R. F. Curl, Jr., Albert C. Kunkle, James W. Bransford, John Rastrup-Andersen, and Jack Rosenthal. J. Chem. Phys., 40: 3378-90(June 1, 1964).

Some 69 microwave absorption lines from three isotopic modifications of $NO_2$ were observed and identified. This spectrum has been completely analyzed in terms of moments of inertia, magnetic fine structure, and centrifugal distortion. Rotational constants, odd electron expectation values, reduced spin-rotation coupling constants, and force constants from combined microwave-infrared data are presented for $^{14}N^{16}O_2$. The magnetic coupling constants are discussed in terms of a simplified electronic structure. The agreement between this structure and the experimental parameters is incomplete, but surprisingly good. Approximate values for the $^{14}N$ quadrupole coupling constants are obtained. (auth)

**27398** ELECTRONIC ENERGY LEVELS OF THE LIGHTER ACTINIDES: $U^{3+}$, $Np^{3+}$, $Pu^{3+}$, $Am^{3+}$, AND $Cm^{3+}$. W. T. Carnall and B. G. Wybourne (Argonne National Lab., Ill.). J. Chem. Phys., 40: 3428-33(June 1, 1964).

The results of a systematic theoretical and experimental study of the energy levels of the light actinides, $U^{3+}$ through to $Cm^{3+}$, in various solution media are presented. Calculations of the "free-ion" levels were made for all these ions and compared with the observed absorption bands. A clear correspondence is found for most of the lower levels. The actinides were found to show very large departures from Russell-Saunders coupling with spin-orbit constants approximately twice those of the corresponding lanthanides. A pronounced tendency towards jj coupling is noted, and its consequences are discussed. (auth)

**27399** ELECTRIC QUADRUPOLE CONTRIBUTION TO CHEMICAL SHIFTS IN LIQUIDS INDUCED BY INTRAMOLECULAR HINDERED ROTATIONS. James D. Ray (Georgia Inst. of Tech., Atlanta). J. Chem. Phys., 40: 3440-1 (June 1, 1964).

Nitrogen-15 nuclear magnetic resonances of liquids having natural abundance of 0.36% $^{15}N$ were observed for the first time. The chemical shifts of $^{14}N$ resonances are plotted against chemical shifts of $^{15}N$ resonances showing the effect of intramolecular barriers to rotation in inducing electric quadrupole contributions to chemical shifts of $^{14}N$ resonances. Observations on the existence and magnitude of various barriers are discussed in relation to previous findings. (D.C.W.)

**27400** KINETICS OF HIGH-TEMPERATURE OXIDATION OF MOLYBDENUM BY DISSOCIATED OXYGEN. Daniel E. Rosner and H. D. Allendorf (AeroChem Research Labs., Inc., Princeton, N. J.). J. Chem. Phys., 40: 3441-2 (June 1, 1964).

The oxidation of molybdenum by $O_2$ and O atoms was investigated at temperatures from 1000 to 1500°K. The oxidation probability for O atoms was found to exceed that for $O_2$ by more than two orders of magnitude. The data for O atoms also reveal simple first-order kinetics. The observed activation energy and kinetic order indicate that the enhanced oxidation probability of O atoms is due to direct attack by a Rideal-type mechanism rather than a simple increase in the steady-state oxygen adatom coverage. (D.C.W.)

**27401** COMMENTS ON THE SPECTRUM OF $Nd^{3+}$ IN $LaCl_3$. E. H. Carlson (Univ. of Alabama, University). J. Chem. Phys., 40: 3444(June 1, 1964).

In fitting the observed energy levels of $Nd^{3+}$ by adjusting the parameters of a crystal field model, Einstein changed the assignment of crystal quantum numbers of some observed components. A discrepancy with the experimental data produced by his assignment of $\mu = 3/2$ rather than $1/2$ to line $C_5$ at 15948.12 $cm^{-1}$ is discussed, including fitting of the data with the original assignment. (D.C.W.)

**27402** INDIRECT NUCLEAR SPIN-SPIN COUPLING AND ISOTOPE SHIFTS IN THE NUCLEAR MAGNETIC RESONANCE OF $^{15}NH_3$, $^{15}NH_2D$, AND $^{15}NHD_2$. R. A. Bernheim and H. Batiz-Hernandez (Pennsylvania State Univ., University Park). J. Chem. Phys., 40: 3446-7(June 1, 1964).

The proton magnetic resonance of a liquid mixture of $^{15}NH_3$, $^{15}NH_2D$, and $^{15}NHD_2$ was observed at 40 Mcps, and the shifts and splittings were measured. Notably, the proton-deuteron spin coupling constant is the same in both $^{15}NHD_2$ and $^{15}NH_2D$. Also, the variation of the isotope shift with successive deuterium substitution in almost linear. The proton-proton coupling constant was evaluated from the proton-deuteron constant, and the proton spin-spin interaction was theoretically examined. (D.C.W.)

**27403** ANOMALIES IN THE NMR AND EPR SPECTRA OF $XeF_6$–HF MIXTURES. Thomas H. Brown, Paul H. Kasai, and Peter H. Verdier (Union Carbide Research Inst., Tarrytown, N. Y.). J. Chem. Phys., 40: 3448-9 (June 1, 1964).

A single broad line with $T_2 < T_1$ was previously observed in the $^{19}F$ NMR spectrum of $XeF_6$ in HF. The width and shift of the line depend upon the $XeF_6$ concentration, while the width is independent of the magnetic field. $T_2 < T_1$ indicates line broadening due to chemical exchange. It appears that a third species with appreciable $^{19}F$ shift is involved in the $^{19}F$ exchange. The presence of a third species was confirmed by observation of a resolved EPR spectrum after most of the HF had evaporated. The experimental results can be explained in terms of a paramagnetic contaminant or a low-lying triplet electronic state in $XeF_6$. (D.C.W.)

**27404** VISCOSITY OF HYDROGEN, DEUTERIUM, METHANE, AND CARBON MONOXIDE FROM −50° TO 150°C BELOW 200 ATMOSPHERES. A. K. Barua, M. Afzal, G. P. Flynn, and J. Ross (Brown Univ., Providence). J. Chem. Phys., 41: 374-8(July 15, 1964).

The absolute viscosities of $H_2$, $D_2$, $CH_4$, and CO were determined from measurements in a capillary-flow viscometer in the temperature range from −50° to 150°C and at pressures below 200 atm with an average precision of 0.1%. The accuracy of the measurements, with some exceptions, is estimated to be about 0.2%. Comparison of the $H_2$ and $D_2$ viscosities appears to confirm a difference between their intermolecular potentials. (auth)

**27405** INFRARED SPECTRA OF THE LITHIUM HALIDE MONOMERS AND DIMERS IN INERT MATRICES AT LOW TEMPERATURE. S. Schlick and O. Schnepp (Israel Inst. of Tech., Haifa). J. Chem. Phys., 41: 463-72(July 15, 1964).

The infrared absorption spectra of lithium fluoride, chloride, and bromide vaporization products were investigated between 2–37 $\mu$ in solid argon, krypton, xenon, and nitrogen matrices at liquid-hydrogen and liquid-helium temperatures. Both the natural lithium salts containing 93% $^7Li$ and $^6Li$ salts as well as equimolar isotopic mixtures were studied. The solvent shifts of the monomers were found to confirm the isotopic invariance of the ratio $\Delta\omega/\omega$ as predicted by Buckingham. Serious deviations from the Kirkwood–Bauer–Magat relation were, however, observed. These shifts were also discussed in terms of specific solute–solvent interactions. Two dimer vibrational frequencies were definitely characterized by means of isotopic substitutions and these frequencies were assigned. They represent in-plane stretching modes of the planar rhombus, the higher energy vibration being of symmetry $b_{3u}$ (X–X axis polarized) and the lower energy vibration $b_{2u}$ (Li–Li axis polarized). (auth)

**27406** NUCLEAR QUADRUPOLE RESONANCE OF $^{115}In$ IN $InI_3$. H. R. Brooker and T. A. Scott (Univ. of Florida, Gainesville). J. Chem. Phys., 41: 475-7(July 15, 1964).

The three lower-frequency pure quadrupole resonance lines of $^{115}In$ in $InI_3$ were studied at several temperatures in the range between 4.2°K and room temperature. The quadrupole coupling constant, the asymmetry parameter, the linewidths, and rough measurements of some of the relaxation times are reported. Pressure-dependence studies at pressures up to 2000 bars were also made. A pressure-induced phase change was detected and investigated. This

phase change was found to be extremely sluggish for samples at low temperatures. (auth)

**27407** MODEL FOR THE HYDRODYNAMIC BOUNDARY CONDITIONS AT A SURFACE VAPORIZING UNDER HIGH TEMPERATURES AND PRESSURES. W. G. Vulliet (General Atomic Div., General Dynamics Corp., San Diego, Calif.). J. Chem. Phys., 41: 521(July 15, 1964).

The hydrodynamic theorems describing the conservation of energy, momentum, and mass flux are applied on each side of a vaporizing surface, and, further, the mass flux is assumed to be proportional to the difference of the chemical potentials of the vapor and condensed phases. Assuming that heat conduction is negligible, there is also conservation of the total energy (enthalpy and kinetic) of the vapor. From these theorems and assumptions, a simultaneous set of equations is derived which relates the thermodynamic properties of the vapor and condensed phases to the downstream hydrodynamic field and the heating rate of the condensed phase. For small vaporization rates, the set reduces to give the same dependence of the vapor pressure on the vaporization rate as that given by the kinetic calculation of Kucherov and Rikenglaz, but gives a different relation between the temperature drop across the surface and the vaporization rate than previously calculated. (auth)

**27408** MICROWAVE SPECTRUM OF XENON OXYTETRAFLUORIDE. Joseph Martins and E. Bright Wilson, Jr. (Harvard Univ., Cambridge, Mass.). J. Chem. Phys., 41: 570-1(July 15, 1964).

The microwave spectrum of $XeOF_4$ was investigated at 20 to 40 Bc with a conventional Stark modulated spectrometer to determine structure parameters. Transitions were observed for five naturally occurring isotopes of xenon in the $^{16}O$ species and for two of these isotopes in an $^{18}O$-enriched sample. From the rotational constants of the various isotopic species the structural parameters, based on a C4v model, were calculated. Because the xenon atom lies on 0.1 ± 0.03 Å from the center of mass of the molecule, the uncertainty in its location is relatively large and introduces large uncertainties in the rest of the structure. (C.E.S.)

**27409** PERIODICALLY PULSED NUCLEAR MAGNETIC DOUBLE RESONANCE. Sidney L. Gordon and John D. Baldeschwieler (Harvard Univ., Cambridge, Mass.). J. Chem. Phys., 41: 571-3(July 15, 1964).

A technique is described that allows single-resonance line intensity changes to be observed in the presence of an arbitrarily strong second r-f field. The experimental procedure is to record the frequency sweep spectra while the second r-f field is periodically pulsed on and off at a pulse frequency that is less than the linewidths of the irradiated transitions. In this limit the spectra consist of a superposition of single- and double-resonance features. The technique is illustrated with the proton spectra of the nuclear spin system $CHFCl_2$. (C.E.S.)

**27410** CRYSTAL-FIELD THEORY AS AN OPERATOR-EQUIVALENT SCHEME. J. S. Griffith (Manchester Coll. of Science and Tech., Eng.). J. Chem. Phys., 41: 576-7 (July 15, 1964).

An attempt is made to clear up the problems associated with the point-charge crystal-field theory for transition-metal compounds. The crystal-field theory is discussed as an operator-equivalent formalism as opposed to a physical model. The formalism is applied to d electrons for a ligand lying along the z axis. The electrostatic potentials are represented by a linear form in unit tensor operators. (C.E.S.)

**27411** AN INTERPRETATION OF THE MÖSSBAUER SPECTRA OF SOME INORGANIC TIN COMPOUNDS IN TERMS OF THE OXIDATION STATE OF THE TIN ATOM. M. Cordey-Hayes (Univ. of Birmingham, Eng.). J. Inorg. Nucl. Chem., 26: 915-23(June 1964).

The Mössbauer spectra of twenty inorganic compounds of Sn were studied. A shift in the resonant absorption frequency occurs when the $^{119}Sn$ nuclei are situated in different chemical environments. The results are correlated with the electronic structures of the two oxidation states of Sn and an estimate of the ionicities of the bonding orbitals made. In addition, a nuclear quadrupole interaction splits the absorption line into two components in many of the divalent compounds studied. Here the results are interpreted in terms of the p character and hybrid nature of the bonding and non-bonding orbitals. A value of $0.5 \times 10^{-25}$ $cm^2$ for the magnitude of the quadrupole moment of the $+^3/_2$ excited state was also obtained. (auth)

**27412** THE HAFNIUM TETRAFLUORIDE–WATER SYSTEM. C. E. F. Rickard and T. N. Waters (Univ. of Auckland, New Zealand). J. Inorg. Nucl. Chem., 26: 925-30(June 1964).

The compounds $HfF_4 \cdot 3H_2O$; $HfF_4 \cdot H_2O$; $Hf_3OF_8 \cdot H_2O$; $Hf_2OF_6$, and $Hf_3O_2F_8$ were characterized by chemical analysis and x-ray powder diffraction. Their properties suggest that they are constitutionally different from the previously reported Zr fluoride hydrates of similar stoichiometry. (auth)

**27413** DOUBLE AMMONIUM OXALATES OF THE RARE EARTHS AND YTTRIUM. M. F. Barrett, T. R. R. McDonald, and N. E. Topp (National Chemical Lab., Teddington, Middx., Eng.). J. Inorg. Nucl. Chem., 26: 931-6 (June 1964).

The rare earths and Y are precipitated by oxalic acid from acidic solutions, on the addition of ammonia, as double salts of the structure $NH_4LnOx_2 \cdot yH_2O$ where y = 1 or 3. Precipitation is carried out from strongly acid solutions of the light earths, and less strongly acidic solutions of the heavy earths and Y. The normal and double oxalates were examined by x-ray methods, and nine different powder patterns were obtained. The Y salt, $NH_4YOx_2 \cdot H_2O$, has a monoclinic structure. Pyrolysis of the double oxalates was studied; the salts all decompose at lower temperatures than the normal oxalates. (auth)

**27414** STABILITY OF SOME INORGANIC AND ORGANIC COMPLEX COMPOUNDS OF ZIRCONIUM AND HAFNIUM. D. I. Ryabchikov, I. N. Marov, A. N. Ermakov, and V. K. Belyaeva (Vernadskii Inst. of Geochemistry and Analytical Chemistry, Academy of Sciences, USSR). J. Inorg. Nucl. Chem., 26: 965-80(June 1964).

The results of investigations on equilibrium reactions in the complexing of ions of $Zr^{4+}$ and $Hf^{4+}$ with inorganic and organic addends are reported. The behavior of these elements in sulfate, nitrate, and chloride solutions was investigated. Oxalic acid and a number of carboxylic and hydroxycarboxylic acids were selected as organic complexing agents. Ion exchange was used to determine the compositions and stability constants of the complex compounds of Zr and Hf. The results are discussed, and data are tabulated. (P.C.H.)

**27415** STUDIES ON THE HYDROLYSIS OF METAL IONS. XLIV. EXTRACTION STUDY OF THE HYDROLYSIS OF VANADIUM(V) AT VERY LOW CONCENTRATION IN ACID PERCHLORATE MEDIA. D. Dyrssen and T. Sekine (Royal Inst. of Tech., Stockholm). J. Inorg. Nucl. Chem., 26: 981-91(June 1964).

The distribution of carrier-free $^{48}V$ between methyl isobutyl carbinol (hexol) and 0.5 M (H,$NaClO_4$) was measured radiometrically at 25°C as a function of −log [$H^+$]. Both curve-fitting and Letagrop adjustment with a high-speed computer were used to evaluate constants for the equilibria. (P.C.H.)

**27416** CHLORIDE, NITRATE AND SULPHATE COMPLEXES OF EUROPIUM(III) AND AMERICIUM(III). B. M. L. Bansal, S. K. Patil, and H. D. Sharma (Atomic Energy Establishment, Trombay, India). J. Inorg. Nucl. Chem., 26: 993-1000(June 1964).

The stability constant for chloride, nitrate, and sulfate ions with Eu(III) and Am(III) was determined at ionic strength of 1 by the ion exchange method, the values of $\beta_1$ for chloride and nitrate complexes of Eu being 0.8 and 1.4, respectively, in 1M acid and those of Am being 0.9 and 1.4, respectively. The values of $\beta_1$ and $\beta_2$ for sulfato complexes of Eu are 17 and 50 in 1M acid. The values of stability constants were also determined at pH 3, and are higher than the corresponding values at 1M acid though ionic strength is 1 in both cases. The values differ with the ones previously obtained using di-p (1,1,3,3-tetramethylbutyl)phenyl phosphoric acid as extractant for nitrate and chloride ions. The values obtained by the TTA method for sulfato complexes agree well with the ion exchange method The values of stability constant for Eu(III) and Am(III) for all these ligands are almost the same, even though their ionic radii differ. (auth)

**27417** STABILITY CONSTANTS OF NITRATE AND SULPHATE COMPLEXES OF PLUTONIUM(IV). T. S. Laxminarayanan, S. K. Patil, and H. D. Sharma (Atomic Energy Establishment, Trombay, India). J. Inorg. Nucl. Chem., 26: 1001-9(June 1964).

The stability constants for nitrato complexes of Pu(IV) were determined by the solvent extraction method using tri-n-butyl phosphate (TBP) as solvent. It was found that the values of stability constants are higher than the ones obtained by other methods. The method of calculation was modified so as to minimize the effect of other complexes that are formed by TBP in the presence of aqueous nitrate solutions. The values, thus obtained, agree fairly well with the published ones, although the activity coefficients for $HNO_3 \cdot TBP$ were not taken into account. The stability constants for sulfate ions with Pu(IV) were also determined in nitrate media. The values obtained at various nitrate and H ion concentrations for sulfato complexes agree fairly well showing that the mixed species are present in very small amounts and are neglected in the method of calculation. (auth)

**27418** THE ELECTRON EXCHANGE REACTION BETWEEN URANIUM(IV) AND THALLIUM(III) IN WATER-METHANOL MEDIA. F. A. Jones and E. S. Amis (Univ. of Arkansas, Fayetteville). J. Inorg. Nucl. Chem., 26: 1045-56(June 1964). (TID-18916)

The kinetics of the reaction U(IV) + Tl(III) → U(VI) + Tl(I) were studied at 15, 20, and 25°C in 25, 50, and 75 wt % methanol–water–perchloric acid solutions. Orders with respect to U(IV), Tl(III), and perchloric acid were found to depend strongly on the solvent composition. Specific velocity constants and thermodynamic quantities of activation are presented. A mechanistic expression was developed to account for these orders in 25% methanol solutions. The effect of variation of ionic strength and the specific effects of various anions and cations on the rate were examined in 75% methanol solutions. The salt effects were strikingly different from those found in aqueous solutions. (auth)

**27419** KINETICS OF THE ISOTOPIC HALOGEN EXCHANGE BETWEEN TRANS-DICHLOROBISETHYLENEDIAMINE PLATINUM(IV) ION AND AQUEOUS CHLORIDE. G. L. Johnson (Univ. of Illinois, Urbana), J. C. Bailar, Jr., and R. H. Herber. J. Inorg. Nucl. Chem., 26: 1061-8(June 1964).

The exchange of chloride ion with trans-$Pt(en)_2Cl_2^{2+}$ was shown to follow a first order rate law with respect to both reactants and catalysts. Both $Pt(NH_3)_4^{2+}$ and $Pt(en)_2^{2+}$ were effective catalysts for the exchange, but $K_2PtCl_4$ and $Pd(NH_3)_4^{2+}$ were ineffective. The rate is independent of acidity but shows dependence on the ionic strength of the solution. The specific rate constant at 20°C, $E_{act}$, $F_{act}$, and $S_{act}$ for the exchange are $3.91 \times 10^1$ $l^2/mole^2/sec^1$, 8.01 kcal/mole, 14.61 kcal/mole, and −23.76 eu, respectively. (auth)

**27420** NEW ACTIVITY COEFFICIENTS OF 0-100 PER CENT AQUEOUS NITRIC ACID. W. Davis, Jr., and H. J. de Bruin (Oak Ridge National Lab., Tenn.). J. Inorg. Nucl. Chem., 26: 1069-83(June 1964).

The ratio of the stoichiometric activity coefficient of anhydrous nitric acid to that of the acid infinitely dilute in water was determined to be 21.0 by combining new transpiration data on the partial pressures of nitric acid over its 2 to 16 M aqueous solutions with literature data on partial pressures and literature values of activity coefficients calculated from freezing-point measurements. From this ratio and the above-mentioned data a new table of values of the stoichiometric activity coefficient at 25°C and for 0 to 100% $HNO_3$ was derived. The values were used to calculate water activities of the solutions by means of the Gibbs–Duhem equation, and mean ionic and molecular activity coefficients by combining them with literature data on the degree of dissociation of the acid into ions. Activity coefficients of the molecular species, on the molar or molal scales, are described very well by the McKay equation up to 14 M acid. Other quantities deduced from the numerical analyses are the dissociation constant and the ratio of the activity coefficient of molecular nitric acid in the pure acid to its value when the acid is infinitely dilute in water. Values of 15.4 ± 2.1 and 18.8 ± 2.3 were obtained for the dissociation constant as ordinarily defined, with two different methods of analyzing results. (auth)

**27421** DISTRIBUTION OF NITRIC ACID BETWEEN WATER AND ORGANIC SOLVENTS, CONTAINING TRI-N-OCTYL AMINE. [PART] II. J. M. P. J. Verstegen (Institutt for Atomenergi, Kjeller, Norway). J. Inorg. Nucl. Chem., 26: 1085-1102(June 1964).

Previous measurements on the distribution of $HNO_3$ between water and organic solvents containing trioctylamine (TOA) are extended. Viscosity and conductivity of the equilibrated amine phases can be explained by ion-pair behavior in solvents of low dielectric constant. Formation of micelles or colloids is not likely. Hydration occurs and solvation was found in chloroform solutions. It was concluded that a compound $(TOAH)NO_3 \cdot HNO_3$ is formed by hydrogen bonding and that the equilibrium constant depends on the solvent, but not significantly on the temperature. (auth)

**27422** THE PURIFICATION OF HELIUM-3. J. Pritchard, D. S. Urch, and M. J. Welch (Univ. of London). J. Inorg. Nucl. Chem., 26: 1121-2(June 1964).

A method is described for the purification of $^3He$, in which impurities are adsorbed on to a finely divided metal film. The method is more efficient than the copper oxide

method, and no $^3He$ is wasted as a result of the purification. (P.C.H.)

**27423** URANIUM OXIDE TELLURIDE. A. J. Klein Haneveld and F. Jellinke (Rijksuniversiteit, Groningen, Netherlands). J. Inorg. Nucl. Chem., 26: 1127-8(June 1964).

X-ray powder diffractometry studies were made on uranium oxide telluride, UOTe. The compound was found to possess a tetragonal structure of the PbFCl type with unit-cell dimensions of UOTe: a = 4.004Å, c = 7.491Å, and c/a = 1.871. (P.C.H.)

**27424** CARBON ISOTOPE EFFECTS IN THE PYROLYTIC DECOMPOSITION OF ZINC OXALATE. Peter E. Yankwich and Petros D. Zavitsanos (Univ. of Illinois, Urbana). J. Phys. Chem., 68: 1275-8(June 1964). (TID-20282)

The $^{13}C$ isotope fractionation in the pyrolytic decomposition of anhydrous zinc oxalate (prepared from the dihydrate precipitating upon admixture of solutions of zinc nitrate and sodium oxalate) has been studied as a function of temperature. Between 282 and 500°, the intramolecular isotope effect observed at complete reaction falls from 0.79 to 0.36‰, thus exhibiting normal magnitude and temperature dependence (the lead and manganous oxalate systems serving for comparison). Ab initio calculations of the intramolecular isotope effect via the Wilson–Johnston method, and employing a three-particle model C–O–Zn, replicate the experimental results well. In one experiment at 300°, the intramolecular and both the intermolecular isotope effects were measured for 0–2% and 2–4% decomposition. The intramolecular isotope effects at complete and partial decomposition are the same, as expected for this type of zinc oxalate. The pattern of intermolecular isotope effects is the same as observed in the manganous oxalate pyrolysis (dependent upon degree of decomposition) and may afford a useful probe for elucidation of mechanisms operating in early stages of such crystal decompositions. (auth)

**27425** LATTICE CONSTANTS AND THERMODYNAMIC PARAMETERS OF THE HYDROGEN–PLATINUM–PALLADIUM AND DEUTERIUM–PLATINUM–PALLADIUM SYSTEMS. Arnulf Maeland and Ted B. Flanagan (Univ. of Vermont, Burlington). J. Phys. Chem., 68: 1419-26(June 1964).

Absorption isotherms (25°) and thermodynamic parameters of absorption of deuterium by several platinum–palladium alloys were determined. Relationships between the relative resistance of the alloys and their deuterium content were established (25°). Results were compared to the previously obtained data on the hydrogen–platinum–palladium system. The experimental differences between the heats of absorption of deuterium and hydrogen in palladium and several platinum–palladium alloys were compared to predicted values for these differences. Lattice constants of the fcc platinum–palladium alloys were determined as a function of both the hydrogen and deuterium content of the alloys. Phase boundaries were established using x-ray diffraction techniques. (auth)

**27426** NUCLEAR MAGNETIC RESONANCE STUDIES OF ADSORPTION ON THORIUM OXIDE. Wallace S. Brey, Jr., and Kenneth D. Lawson (Univ. of Florida, Gainesville). J. Phys. Chem., 68: 1474-81(June 1964).

Nuclear magnetic resonance line widths and relaxation times were measured for water, methyl alcohol, ethyl alcohol, and butylamine adsorbed on thorium oxide. The source of the thorium oxide and the conditions of its activation influence the relaxation times of the adsorbate. Temperature dependence studies of the relaxation times of adsorbed water permit an estimate of the activation energy for the motions producing relaxation of the adsorbed molecules. Similar studies for the organic molecules lead to a quite different sort of information: it is possible to see in the line width thermal transitions corresponding to the successive loss of motional freedom of various parts of the molecule. Line width behavior seems also to be related to the ratio of molecular diameter to pore size. (auth)

**27427** VAPORIZATION OF THORIUM DICARBIDE. Donald D. Jackson, George W. Barton, Jr., Oscar H. Krikorian, and Ray S. Newbury (Univ. of California, Livermore). J. Phys. Chem., 68: 1516-23(June 1964). (UCRL-7638)

A mass spectrometric investigation was carried out on the vaporization processes and thermodynamics of vaporization of solid $ThC_2$. The carbide was heated in a graphite Knudsen cell and the vapors were analyzed. The partial pressures of Th(g) and $ThC_2$(g) in equilibrium with the carbon-saturated solid were found to be of comparable magnitude in the temperature range investigated, 2371 to 2642°K. The enthalpy of sublimation of $ThC_2$(s) to $ThC_2$(g) is 198.1 ± 3.5 kcal/g.f.w., and to Th(g) is 168.4 ± 3.5 kcal/g.f.w. The calculated $\Delta H^0_{1298}$ of formation of $ThC_2$ is −30.7 ± 3.7 kcal/g.f.w. (auth)

**27428** MEASUREMENT OF FORMAL OXIDATION-REDUCTION POTENTIALS OF CERIUM(IV)–CERIUM(III) SYSTEM IN ACETONITRILE. G. Prabhakar Rao and A. R. Vasudeva Murthy (Indian Inst. of Science, Bangalore). J. Phys. Chem., 68: 1573-6(June 1964).

The oxidation-reduction potentials of Ce(IV)–Ce(III) in acetonitrile were measured at 25°C using $Ag–AgNO_3$ (acetonitrile) and aqueous-saturated calomel electrodes as reference half cells. The formal potential vs the $Ag–AgNO_3$ electrode was found to be 0.755 ± 0.002 v while that vs the calomel electrode was 1.056 ± 0.002 v, and the potential on the standard hydrogen scale is 1.300 ± 0.002 v. The effects of added glacial acetic acid on the potential were also determined; when the acetic acid concentration was more than 1000 times that of Ce, a steady value of 1.418 v on the hydrogen scale was obtained. The increase from 1.300 to 1.418 v was determined to be due to complex formation between cerous ion and acetic acid. (D.L.C.)

**27429** STUDY OF THE ELECTRONIC STRUCTURE OF CARBIDES OF THORIUM, URANIUM, AND PLUTONIUM. P. Costa and R. Lallement (CEN, Fontenay-aux-Roses, France). J. Phys. Chem. Solids, 25: 559-64(June 1964). (In French)

The resistivity and the thermoelectric power of thorium, uranium, and plutonium monocarbides were measured from 4.2 to about 1200°K. The work showed that ThC becomes a superconductor at about 9°K, and that PuC undergoes a magnetic type transformation at about 100°K. Analysis of the resistivities and the thermoelectric powers and the values of the densities of states at the Fermi level deduced from other experiments indicated that the band structure of these carbides must include a narrow band. It is suggested that ThC should be similar to a transition metal carbide, with a narrow d band, that UC should show a mixed d-f band, and that PuC should be analogous to a rare earth carbide, with well localized f electrons. (auth)

**27430** EFFECTS OF ALKALI METAL ADMIXTURES ON THE REDUCTION KINETICS OF URANIUM TRIOXIDES BY CARBON OXIDE. V. G. Vlasov and V. N. Shalaginov (Ural Poltechnic Inst., USSR). Kinetika i

Kataliz, 5: 263-7(Mar.-Apr. 1964). (In Russian)

The influence of $Li_2CO_3$, $Na_2CO_3$, and $K_2CO_3$ additions on the kinetics of the rate of reduction of $UO_3$ by carbon monoxide was analyzed. The rate of the reduction process is slightly reduced by $Li_2CO_3$ additions and considerably enhanced by $Na_2CO_3$ and $K_2CO_3$. (tr-auth)

**27431** POSITION OF HYDROGEN IN THE PERIODIC SYSTEM OF ELEMENTS. Harriman H. Dash (Nassau Hospital, Mineola, N. Y.). Nature, 202: 1001-3(June 6, 1964).

The position of H in the periodic system of elements as proposed by others is evaluated. The all-important roles of H, with its concomitant energy and entropy relation, stem from the uniqueness of its structure-property characteristics. The position of H in the periodic system of elements is fundamental to biotic processes. The uniqueness of the first quantum shell residues in the peculiarity that, while H and He both belong to s orbitals, they exhibit chemical properties typical of p orbitals. The validity of this uniqueness is revealed by some very interesting relations shown by the atomic radii and boiling points of the elements. However, there is a conclusive and unambiguous answer to the problem. Structurally, the only position that can be assigned to H is $1s^1$, that is, position one of the s orbital belonging to the first (n = 1) quantum shell. This has been well established by quantum mechanics. (P.C.H.)

**27432** INTERACTION OF ALKALI EARTH METALS WITH $H_2O$. L. Bass and T. Pyle (Lanchester College of Tech., Coventry, Eng.). Nature, 202: 1003(June 6, 1964).

An approximation of the previously proposed quantitative theory of spontaneous interactions between metals and polar (particularly aqueous) electrolytes predicts the dissolution of alkali metals, and is also consistent with the actual interactions of all pure metals with water. It is noted that the special considerations, as well as the entire theory, involve in their formulation only quantities measurable on the two phases in their pure states. (P.C.H.)

**27433** URANYL SPECTRA IN ORGANIC MEDIA. T. H. Siddall, III, and C. A. Prohaska (E. I. Du Pont de Nemours and Co., Aiken, S. C.). Nature, 202: 1088-90(June 13, 1964).

Studies of uranyl spectra in organic solutions of the adducts that uranyl salts form with organophosphorus and organonitrogen compounds indicated an irregular multiplet, probably a quarter, as the first excited state. Most of the spectra bands obtained for aqueous uranyl ions were observed very close to the given frequencies in the spectra for the organic compounds. Additional peaks were also observed. There was a relatively high intensity of bands at lower spectra. It was concluded that there are four series for uranyl nitrate adducts with leading bands at about 20,500, 21,300, 23,100, and 27,100 $cm^{-1}$. (M.C.G.)

**27434** MÖSSBAUER EFFECT HYPERFINE STRUCTURE OF TRIVALENT $Fe^{57}$ IN CORUNDUM. G. K. Wertheim and J. P. Remeika (Bell Telephone Labs., Murray Hill, N. J.). Phys. Letters, 10: 14-15(May 15, 1964).

A detailed analysis of the well-resolved nuclear hyperfine structures corresponding to the various crystal-field states of the $^6S_{5/2}$ ion, $^{57}Fe^{3+}$, in corundum is presented. (C.E.S.)

**27435** THE CUBIC FIELD POTENTIALS OF RARE EARTH IONS IN CALCIUM FLUORIDE. E. L. Offenbacher and L. Shapiro (Temple Univ., Philadelphia). Phys. Letters, 10: 16-18(May 15, 1964).

The cubic crystal field potential of rare earth ions in calcium fluoride crystals is discussed. Evidence is presented that the sixth order potential is of the order of 10 to 25% of the fourth order potential in $CaF_2$, that the ratio of the crystal field parameters R decreases with atomic number Z, that the ratio R has different behavior for divalent and isoelectronic trivalent ions, and that the magnitude of R in CaO and MgO is of the same order but smaller than in $CaF_2$. (C.E.S.)

**27436** ELECTRICALLY INDUCED POPULATION INVERSION OF THE NUCLEAR MAGNETIC RESONANCE OF $Na^{23}$ IN $NaClO_3$. M. Luukkala (Univ. of Turku, Finland). Phys. Letters, 10: 20-1(May 15, 1964).

Observations of the saturation and population inversion of the center NMR line in $NaClO_3$ are reported. The $(3/2 \rightleftharpoons -1/2)$ and $(-3/2 \rightleftharpoons 1/2)$ electric quadrupole transition frequencies were simultaneously excited with an electric field while the central $(1/2 \rightleftharpoons -1/2)$ line of $^{23}Na$ in $NaClO_3$ was inspected at 77°K with a slow passage NMR spectrometer at ~ 7.9 Mc. (C.E.S.)

**27437** FERROMAGNETIC RESONANCE OF EuO. J. F. Dillon, Jr. (Bell Telephone Labs., Murray Hill, N. J.) and C. E. Olsen. Phys. Rev., 135: A434-6(July 20, 1964). (LADC-5972)

Ferromagnetic and paramagnetic resonance was observed with single crystals of europous oxide. The frequencies used were 23.8 and 27.5 Gc, and the temperatures ranged from 1.5 to 300°K. The linewidth increased from about 800 Oe at low temperatures to about 1400 Oe at room temperature. The low-temperature anisotropy field is given approximately by $K_1/M = -190$ Oe. (auth)

**27438** EXTENSION OF SUBMILLIMETER WAVE SPECTROSCOPY BELOW A HALF-MILLIMETER WAVELENGTH. Gordon Jones and Walter Gordy (Duke Univ., Durham, N. C.). Phys. Rev., 135: A295-6(July 20, 1964).

The methods of high-resolution microwave spectroscopy were extended to $\lambda = 0.43$ mm. The $J = 5 \rightarrow 6$ rotational line of $^{12}C^{16}O$ was measured to be 691,472.60 ± 0.60 Mc. With other measured lower frequency transitions, this value leads to a centrifugal stretching constant $D_0 = 0.18390 \pm 0.00014$ Mc and to $B_0 = 57,635.970 \pm 0.003$ Mc for $^{12}C^{16}O$. Measurements of the three hyperfine components of the $J = 0 \rightarrow 1$ transition of $H^{35}Cl$ at $\lambda = 0.48$ mm yield for this molecule $\nu_0 = 625,919.24 \pm 0.52$ Mc and $B_0 = 312,991.30 \pm 0.26$ Mc. With the infrared value of $B_0$ in wavelength units measured with great accuracy by Rank and his associates, the $B_0$ value yields the spectral value $c = 299,792.8 \pm 0.4$ km/sec for the velocity of light. This value is in agreement with, and is of comparable accuracy to, the best values obtained by other more direct methods for the measurement of c. (auth)

**27439** CONCENTRATION-DEPENDENT ELECTRON SPIN RESONANCE. Gerald Burns (International Business Machines Corp., Yorktown Heights, N. Y.). Phys. Rev., 135: A479-81(July 20, 1964).

The decrease of the intensity of a nuclear magnetic resonance (NMR) line as one adds impurities to the specimen was previously studied. Usually the intensity of the line is $\propto (1 - c)^n$, where c = the concentration of the impurities and n is the so-called wipe-out number, i.e., if the impurity is within a sphere containing n neighboring positions its effect is large enough so as to cause a nuclear quadrupole splitting of the host nuclei so that they no longer contribute to the NMR line. Experimentally one can deter-

mine n. The extension of this type of experiment into the domain of electron spin resonance (ESR), in a very simple way, is described. Also, the wipe-out number for $Mn^{2+}$ in two systems, $(Zn_{1-c} + Cd_c)S$ and $Zn(S_{1-c} + Se_c)$, is measured. One finds n = 157 and 270, respectively. (auth)

**27440** SPECTRUM OF LOW FREQUENCIES IN $H_2O$, $D_2O$, AND SOLUTIONS OF HF IN $H_2O$. H. Stiller (Kernforschungsanlage, Julich, Ger. and Studiecentruum voor Kernenergie, Mol, Belg.). Physica, 30: 931-6(Apr. 1964).

Measurements of the energy distribution of scattered neutrons reveal at low frequencies an indication of two peaks in water, a continuous spectrum in heavy water and one peak in aqueous solutions of HF for concentrations of 5, 10, and 25 weight percent. A phenomenological description of the one peak observed for HF in $H_2O$ in terms of the self-correlation function $G_s(r,t)$ suggests that this peak is due to proton fluctuations. (auth)

**27441** AN INFRA-RED STUDY OF THE DEUTERATION OF CELLULOSE AND CELLULOSE DERIVATIVES. R. Jeffries (British Rayon Research Assn., Wythenshawe, Manchester, Eng. and Shirley Inst., Didsbury, Manchester, Eng.). Polymer, 4: 374-89(Sept. 1963).

An infrared study was made of the deuteration of cellulose and cellulose derivatives with deuterium oxide. The deuteration of the crystalline and the amorphous regions of cellulose were investigated in detail. Results were obtained, which suggest that the crystalline regions contain a range of degrees of perfection of the hydrogen-bonding arrangement. It was concluded that the reason for the low rate of deuteration of the crystalline regions is that the latter absorb only very small amounts of deuterium oxide. The results obtained with cellulose acetates and ethyl cellulose indicated that all the hydroxyl groups in these derivatives are readily deuterated. Crystallization or orientation of the acetate films did not affect this complete exchangeability. (auth)

**27442** THE MONOCLINIC-TETRAGONAL TRANSFORMATION AND ASSOCIATED TWINNING IN THIN FILMS OF ZIRCONIA. J. E. Bailey (Central Electricity Generating Board, Berkeley, Glos., Eng.). Proc. Roy. Soc. (London), Ser. A, 27: 395-412(June 9, 1964).

A transmission electron microscopy study was made of the monoclinic to tetragonal phase transformation in thin films of zirconia. The films were prepared by the oxidation and subsequent recrystallization of zirconium foils. The transformation, which is rapid and reversible, is generally accompanied by twinning on (100) and {110} planes. The orientation relations between the two phases and the shape change accompanying transformation were determined. The twinning shears were also measured. Stacking faults on several low index planes were observed in monoclinic zirconia, and dislocations are present in both phases. Cracks occur in the films on transformation from the tetragonal to the monoclinic phase. (auth)

**27443** COPRECIPITATION OF Ce WITH CRYSTALLINE POTASSIUM SULFATE. IV. COPRECIPITATION OF Ce IN CRYSTALLIZATION OF POTASSIUM SULFATE FROM NEUTRAL AQUEOUS SOLUTION. I. V. Melikhov and S. G. Babayan. Radiokhimiya, 6: 153-65(1964). (In Russian)

Changes in the composition of the liquid and solid phases, dimensions, surfaces, and rate of crystal growth in the precipitation of potassium sulfate accompanied by cerium (tagged with $^{144}Ce$) were studied. The process was characterized by carrying of the cerium on well-formed crystals of the macrocomponent. Data for the parameters were tabulated, and curves are presented showing the changes in the variables with changing conditions. Mathematical formulas were developed for the reactions between the various parameters affecting the crystallization process. The experimental data may be explained by considering that the coprecipitation of the cerium with the potassium sulfate depends only on the diffusion of the microcomponent into the crystal of potassium sulfate. This is limited by two simultaneous processes, a fast one and a slow one, of transfer of cerium into the solid phase and a definite effect of diffusion into the solution in the initial stages of the process. (TTT)

**27444** COPRECIPITATION OF Ce WITH CRYSTALLINE POTASSIUM SULFATE. V. CARRYING OF Ce IN CRYSTALLIZATION OF POTASSIUM SULFATE FROM SATURATED AQUEOUS SOLUTION. I. V. Melikhov, E. K. Kirkova, and M. S. Merkulova. Radiokhimiya, 6: 165-72 (1964). (In Russian)

The interaction of cerium with a precipitate of potassium sulfate in its recrystallization from a saturated solution of the macrocomponent was studied. The results showed that the microcomponent exists in the solid phase in two conditions: cerium, probably adsorbed, that rapidly exchanges with the solution; and cerium that is tightly bound to the crystal and returns to the solution only when the crystal is dissolved. From the data an empirical formula was derived for the distribution of the microcomponent, and the constants were determined. With increased aging of the precipitate, the empirical coefficients of the equation decreased significantly. The results were in agreement with published data on the high adsorption ability of potassium sulfate for cerium and the penetration of cerium into potassium sulfate crystals. Formation of the potassium sulfate crystals by solution of minute particles and growth of the larger ones was rapid in the first part (first 10 min) of the recrystallization, which led to the appearance of supersaturation in the solution. It then proceeded more slowly, with the result that the crystal dimensions changed from $r = 10^{-6}$ cm to $\bar{r} = 10^{-4}$ cm after 2 to 3 days. (TTT)

**27445** COMPLEX CERIUM, YTTRIUM, AND URANYL COMPOUNDS WITH POLYAMINOCARBOXYLIC ACIDS. [PART] II. L. M. Razbitnaya. Radiokhimiya, 6: 202-6 (1964). (In Russian)

Data are given on the composition, hydration state, and electrophoresis of compounds of $Ce^{3+}$, $Y^{3+}$, and $UO_2^{2+}$ with diethyltriaminepentaacetic acid and N,N,N',N'-tetraacetic acid diaminodiethyl ether. Calculated and found empirical formulas are given for various complexes. The results obtained indicated that the rare earths and uranyl ions enter into complex amines, saturating their coordinate bonds with atoms of nitrogen and, probably, molecules of water of crystallization. The compounds act like complex acids since hydrogen ions are formed in their inner spheres. These acids have the general formula $H(MeV)\underline{n}H_2O$, where Me is the cation and V is the organic radical. The Me/V ratio for all compounds obtained was 1/1. The complexes formed with $Ce^{3+}$ and $Y^{3+}$ were readily soluble in water, while that of the uranyl ion was considerably less soluble. The complex acids separated out as crystallo-hydrates with an integral number of molecules of water of crystallization, which was lost at temperatures above 100°C. (TTT)

**27446** COMPLEX FORMATION OF PENTAVALENT NEPTUNIUM IN PHOSPHORIC ACID SOLUTIONS BY AN ION EXCHANGE REACTION. A. I. Moskvin and V. F. Peretrukhin. Radiokhimiya, 6: 206-14(1964). (In Russian)

The distribution of trace amounts of neptunium(V) be-

tween phosphate solutions and the cation exchange resin KU-2 in ammonium form was studied. The ion strength of the solutions ($\mu = 0.2$) was maintained with perchloric acid and ammonium perchlorate. The neptunium(V) distribution coefficient between 0.2M ammonium perchlorate and the resin in the absence of complexant was constant at pH from 2.4 to 6.4. This indicated the absence also of complexing reactions such as hydrolysis and polymerization of $NpO_2^+$. The distribution of neptunium(V) between the resin KU-2 and diammonium hydrogen phosphate solution as a function of pH and also of the salt concentration was determined. When the phosphate concentration was 0.05M, by increasing pH from 4.8 to 6.7 the distribution coefficient was decreased greatly, as it also did at constant pH of 6.5 with increasing phosphate concentration from 0.005 to 0.05M. A mathematical treatment of the data obtained indicated that at pH 4.8 to 6.7 the complexes $[NpO_2HPO_4^-]$ and $[NpO_2H_2PO_4]$ are formed. In the phosphate concentration range studied only the first of these complexes is formed. (TTT)

**27447** ADSORPTION OF URANIUM ON POLISHED PLATINUM. A. G. Samartseva. Radiokhimiya, 6: 230-7 (1964). (In Russian)

Experiments were carried out with solutions of uranium oxide dissolved in nitric acid. At uranium concentrations from $10^{-9}$ to $10^{-7}$M and at pH values from 4 to 7, the adsorption of uranium on a polished platinum surface was 40 to 70% in the first hour. The value increased slowly thereafter with time, reaching 60 to 85% in 5 hr. With increasing pH in the uranium solution from 1 to 12, adsorption was maximum at pH 4 to 6 and reached 90%. The reverse reaction, desorption, was rapid from pH 2 to 6, with only about 5% of the uranium remaining at pH 6. However, there was no further desorption from pH 6 to 12. With increasing uranium concentration from $10^{-9}$ to $10^{-6}$M, the isothermal adsorption of the uranium on platinum from nitric acid solution at pH 4.1 followed Freundlich's law. In the presence of foreign ions, hydrogen peroxide significantly decreased the adsorption, and citric acid almost completely prevented it. On fired platinum all adsorption values significantly decreased as a function of pH, but the shape of the adsorption curve was the same as that for unheated platinum. It was concluded that uranium adsorption on platinum is related to occlusion of gases on the surface of the metal. (TTT)

**27448** SELF-DIFFUSION OF Ca-45 INTO CERTAIN CARBONATES. N. Lahav and G. H. Bolt (Agricultural State Univ., Wageningen, Netherlands). Soil Sci., 97: 293-9 (May 1964).

Self-diffusion of $^{45}Ca$ into calcite, dolomite, $CaCO_3$ precipitate, and commercial lime (EMKAL) was measured. The experimental data of the first three carbonates were in agreement with the theoretical diffusion equation and thus enabled the calculation of the self-diffusion constant. Grinding of calcite and dolomite did not influence their self-diffusion constants to a measurable extent. Lack of self-diffusion in EMKAL, which is not pure calcite, suggested a coating of its particles by other compounds, presumably silicates. Experimental evidence with $CaCO_3$ support this suggestion. (auth)

**27449** GENERAL VALENCE FORCE CONSTANTS FOR GROUP (V) B HYDRIDES. Giancarlo De Alti, Giacomo Costa, and Vinicio Galasso (Univ. of Trieste, Italy). Spectrochim. Acta, 20: 965-75(June 1964).

Different sets of force constants for the group (V) B hydrides were calculated using different combinations of experimental frequencies, corrected for the anharmonicity, of wholly hydrogenated, deuterated, and tritiated derivatives. Harmonic frequencies, variance, potential energy distribution, rotational distortion, and Coriolis coupling constants were calculated from every set. A best set of force constants for each representative molecule is proposed. (auth)

**27450** EXPERIMENTAL AND ANALYTICAL STUDIES OF FISSION-PRODUCT RETENTION IN HIGH-TEMPERATURE SODIUM. W. P. Kunkel, D. M. Elliott, and A. S. Gibson (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 94(June 1964).

**27451** THE ELECTRICAL AND THERMAL CONDUCTIVITY OF LIQUID CESIUM TO 3000F AND THE CRITICAL POINT OF CESIUM. Jack M. Hochman and Charles F. Bonilla (Columbia Univ., New York). Trans. Am. Nucl. Soc., 7: 101-2(June 1964).

**27452** SULFUR PRESSURE VARIATION OF MOLYBDENUM DISULFIDE AT 1100°C. S. C. Schaefer (Bureau of Mines, Albany, Ore.), A. H. Larson, and A. W. Schlechten. Trans. Met. Soc. AIME, 230: 594-5(Apr. 1964).

Measurements on the sulfur vapor pressure variation with composition at 1100°C in the homogeneous region of $MoS_2$ were made by reacting: Mo powder (99.97% Mo) with S vapor; and $MoS_{1.99}$ (formed by reaction of Mo + $H_2S$) with S vapor in a quartz capsule. Conditions were controlled to form an equilibrated phase within the homogeneous region of the disulfide. No free S was detected in any of the equilibrated sulfide phases. Calculations showed that $S_2$ is the predominant molecular species at 1100°C and high total S pressures. At lower total S pressures the monatomic species would increase but not to an appreciable level. The extent of S solubility in Mo was determined by equilibrating mixtures of Mo + $MoS_{1.99}$ in short capsules at a constant temperature of 1100°C. The extent of this solubility was found to be 1.49 at. % (0.5 wt %). (P.C.H.)

**27453** MELT DIAGRAM OF THE TERNARY SYSTEM NaF–KF–NaF. I. N. Sheiko, V. S. Kikhno, and V. I. Mel'nikov (Inst. of General and Inorganic Chemistry, Academy of Sciences, Ukrainian SSR). Ukr. Khim. Zh., 29: 1259-64(1963). (In Russian)

An analysis was made of the melt diagrams for NaF–KF–$ZrF_4$ systems. The liquidus surface of the NaF–KF–$ZrF_4$ system consists of eight crystallization fields: $ZrF_4$, $Na_3Zr_4F_{19}$; solid solution $KZrF_5$ and $Na_7Zr_6F_{31}$; solid solution $K_2ZrF_6$ and $Na_2ZrF_6$; $Na_5Zr_2F_{13}$, solid solution $K_3ZrF_7$ and $Na_3ZrF_7$; and NaF and KF. A radiogram also revealed the presence of the compound $KNaZrF_6$. (R.V.J.)

**27454** PRESSURE SYNTHESIS OF NIOBIUM NITRIDES AND CONSTITUTION OF δ-NbN. G. Brauer and H. Kirner (Universität, Freiburg i. B.). Z. Anorg. Allgem. Chem., 328: 34-43(Apr. 1964). (In German)

Niobium nitrides were prepared from niobium metal powder and nitrogen at temperatures of 1200 to 1500°C and pressures up to 160 atm. They belong either to the cubic δ phase or to the hexagonal ε phase. Their maximum nitrogen content corresponds to the formula $NbN_{1.06}$(= $Nb_{0.94}N$). The highest amount of all lattice vacancies of the cubic nitride being filled was found at the composition $NbN_{1.00}$. (auth)

**27455** ON THE QUESTION OF THE GROUND STATE IN THE Tb–I SPECTRUM. I. Bender, S. Penselin, and K. Schuepmann (Universität, Heidelberg). Z. Physik, 179: 4-8(1964). (In German)

In an atomic beam magnetic resonance experiment on

$^{159}Tb$ $\Delta F = 0$ transitions in several hfs levels of thermally excited fine structure states were observed. Detailed analysis of the data showed two $J = {}^{15}/_{2}$ states, one $J = {}^{13}/_{2}$, one $J = {}^{11}/_{2}$, and, probably, one $J = {}^{9}/_{2}$ state to be present. For these levels $g_J$-values are given. It was concluded that the ground state of neutral terbium is $4f^{8}5d\,6s^{2}\,{}^{8}G_{15/2}$. The $4f^{9}\,6s^{2}\,{}^{6}H_{15/2}$ level is considered to lie not more than 1000 $cm^{-1}$ higher. (auth)

**27456** OXYGEN ISOTOPIC EXCHANGE IN THE SYSTEMS $WO_3-O_2$ AND $Na_2W_4O_{13}-O$. V. G. Finikov and G. N. Zykova (Inst. of Physical Chemistry, Academy of Sciences, USSR). Zh. Fiz. Khim., 38: 542-6(Mar. 1964). (In Russian)

The activation energy of the isotopic exchange in the systems $WO_3^{16}-O_2^{18}$ and $Na_2W_4O_{13}^{16}-O_2^{18}$ over the range 400 to 750°C was calculated. The apparent activation energy, calculated according to Arrhenius, in a number of cases possesses anomalous values. The activation energy of isotopic exchange varies regularly with change in temperature also within the temperature limits wherein there is observed a continuous temperature dependence of the degree of exchange. (auth)

**27457** RATE OF DIFFUSION OF PROTONS IN NICKEL OXIDES AND THE OXYGEN OVERVOLTAGE ON A NICKEL OXIDE ELECTRODE. P. D. Lukovtsev and G. Ya. Slaidin (Inst. of Electro-Chemistry, Academy of Sciences, USSR). Zh. Fiz. Khim., 38: 556-61(Mar. 1964). (In Russian)

The rate of diffusion of protons through nickel oxide film and the oxygen overvoltage on the film was investigated for 3.3 N KOH solutions with additions of $Zn^{2+}$, $Al^{3+}$, $W^{6+}$, and $Mo^{6+}$ with the aid of a nickel diffusion electrode coated on one side with an oxide film. It was established that the addition of $Zn^{2+}$ and of $Al^{3+}$ to the KOH solution increases the oxygen overvoltage and lowers the rate of proton diffusion through the oxide film over the entire range of potentials investigated. The addition of $W^{6+}$ and $Mo^{6+}$ lowers the oxygen overvoltage and increases the rate of diffusion of protons in the high potential region and increases the overvoltage and decreases the proton diffusion rate in the low potential region. The proton diffusion rate is independent of the thickness of the oxide film and increases with increase in strength of the cathodic polarization current on the reverse side of the nickel foil. An explanation of the observed relations is proposed based on the assumption that impurity ions from the solution can become incorporated into the nickel oxide lattice in place of Ni ions and thereby change the semiconductor and electrochemical properties of the film. (auth)

**27458** DEPENDENCE OF THE HEAT OF FORMATION OF HAFNIUM CARBIDE UPON THE COMPOSITION. V. I. Zhelankin and V. S. Kutsev. Zh. Fiz. Khim., 38: 562-4(Mar. 1964).

The heat of combustion of a stoichiometric composition is 305.9 kcal/mole; the heat of formation of HfC is 54.2 kcal/mole. With change in composition from $HfC_{0.87}$ to HfC the heat of combustion changes by 28.6 kcal/mole and the heat of formation by 2.5 kcal/mole and by 23 kcal/g atom C. (auth)

**27459** THEORY OF ION EXCHANGE DYNAMICS. VI. ELUTION DYNAMICS OF THE SORPTION OF VARIED VALENCE MICROCOMPONENT IONS. V. V. Rachinskii and S. M. Rustamov (Timiryazev Agricultural Academy, (Moscow)). Zh. Fiz. Khim., 38: 664-71(Mar. 1964). (In Russian)

The elution dynamics of the ion exchange sorption of varied valence microcomponent ions was investigated by means of radiochromatography for the systems $H^+ \rightleftharpoons Ca^{2+}$, $Na^+ \rightleftharpoons Ca^{2+}$, $H^+ \rightleftharpoons Si^{2+}$, $Na^+ \rightleftharpoons Si^{2+}$, and $H^+ \rightleftharpoons Y^{3+}$. The approximate asymptotic equation was used for the theoretical treatment of the dynamic distribution curves. The experimental data are in good agreement with the equation. The sorption constant $\beta$ was also evaluated. The values obtained for the latter are of the same order of magnitude ($\sim$0.1 $sec^{-1}$) as in the case of the frontal dynamics of macrocomponent ions under steady state conditions. The value of $\beta$ for the system $H^+ \rightleftharpoons Y^{3+}$ was found to be three times as high as that for the other systems. (auth)

**27460** ELECTROCHEMICAL PROPERTIES OF ZIRCONYL PHOSPHATE. I. THE ELECTRODE PROPERTIES OF MEMBRANES. E. A. Materova and P. A. Skabichevskii (Leningrad State Univ.). Zh. Fiz. Khim., 38: 676-80(Mar. 1964). (In Russian)

It was found that membrane electrodes reversible toward H, Na, Ca, and Ba ions over a large range of concentrations of the corresponding chlorides can be prepared from zirconyl phosphate. The effect of the composition of the zirconium phosphate specimen on the H function of the membrane electrodes was elucidated. (P.C.H.)

**27461** THERMODYNAMIC STUDIES OF $MeMoO_3$ COMPOUNDS. I. HEAT OF FORMATION OF Sr $MoO_3$ AND $BaMoO_3$. L. A. Zharova and N. G. Barancheeva (Moscow State Pedagogical Inst.). Zh. Fiz. Khim., 38: 752-4(Mar. 1964). (In Russian)

A combustion method in a bomb calorimeter was used for determining the thermal effects in the reactions: $SrMoO_3 + {}^{1}/_{2}O_2 = SrMoO_4$ and $BaMoO_3 + {}^{1}/_{2}O_2 = BaMoO_4$. Equations relating $\Delta Z^{0}_{298}$ and $\Delta H^{0}_{298}$ for sulfites, selenites, and compounds of the type $MeMoO_3$ (Me = metal) were developed and used for determining values of $\Delta Z^{0}_{298}$ for $SrMoO_3$ and $BaMoO_3$. (R.V.J.)

**27462** MECHANISM OF THE ISOTOPIC EXCHANGE OF OXYGEN IN THE SYSTEMS GAS-SOLID AT HIGH TEMPERATURES. V. G. Finikov (Inst. of Physical Chemistry, Moscow). Zh. Fiz. Khim., 38: 833-8(Apr. 1964). (In Russian)

Possible variants of the mechanism of isotopic exchange between gaseous O and O-containing solids at 400 to 800° are discussed. The exchange mechanism includes the stage of chemisorption of molecular O on the surface of the solid. The regular increase in activation energy with temperature as calculated according to the theory of absolute reaction rates is evidence of an energetic inhomogeneity of the surfaces investigated. (auth)

**27463** THEORY OF ION EXCHANGE DYNAMICS. VII. THE DYNAMICS OF THE ION EXCHANGE SORPTION OF DIFFERENT VALENCE IONS IN THE CASE OF A CONCAVE ISOTHERM. V. V. Rachinskii and S. M. Rustamov (Timiryazev Agricultural Academy, [Moscow]). Zh. Fiz. Khim., 38: 885-90(Apr. 1964). (In Russian)

On the example of the sorption dynamics of the different valence ions $Ca^{2+} \rightleftharpoons Na^+$ and $Y^{3+} \rightleftharpoons H^+$ it is shown that the basic principles of the theory of equilibrium sorption dynamics hold for the case of a concave isotherm. There is a practically negligible discrepancy (ca 15%) between the theoretical and experimental assessment of the volume of the regenerate for parameter values $1 < B < 10$ (the system $Ca^{2+} \rightleftharpoons Na^+$). For parameter values $10 < B < 100$ (the system $Y^{3+} \rightleftharpoons H^+$), an accelerating effect was observed in regeneration of the columns, due to change of the concave absorption isotherm into one of linear shape for the frontal region with low concentrations of the displaced ion. (auth)

**27464** EQUILIBRIUM PARTITION FACTOR IN ION EXCHANGE COMPLEXATING CHROMATOGRAPHY. N. N. Matorina (Inst. of Physical Chemistry, Moscow). Zh. Fiz. Khim., 38: 932-8(Apr. 1964). (In Russian)

On the basis of an examination of the principal parameters determining the equilibrium separation factor in ion exchange complexing chromatography, an equation was derived by means of which equilibrium factors of the separation under various conditions can be determined. Another equation was obtained by means of which the conditions for carrying out the process, providing for maximum value of the equilibrium partition factor in the given system are obtained without experimental data. (auth)

**27465** ELECTROCHEMICAL PROPERTIES OF A ZIRCONYL PHOSPHATE. II. ELECTRIC CONDUCTIVITY AND COMPOSITION OF ZIRCONYL PHOSPHATE SPECIMENS. E. A. Materova and P. A. Scabichevskii (Leningrad State Univ.). Zh. Fiz. Khim., 38: 985-9(Apr. 1964). (In Russian)

The electric conductivity of zirconyl phosphates depends on the composition of the specimen. A reduced amount of phosphorus in the specimen reduces the electric conductivity of the zirconyl phosphate. The ability of the specimen to absorb water vapor also affects the electric conductivity of zirconyl phosphates. The electric conductivity of zirconyl phosphates was measured with a buffer solution containing acetic acid and sodium acetate with pH 4.94. It was found that sodium ions are less mobile in zirconyl phosphates than hydrogen ions. The electric conductivity of a zirconyl phosphate with sodium is much lower than with hydrogen. (R.V.J.)

**27466** MAGNETIC SUSCEPTIBILITY OF CERTAIN RHENIUM COMPOUNDS. V. I. Belova, Ya. K. Syrkin, E. G. Ippolitov, A. S. Kotel'nikova, G. K. Babeshkina, and R. A. Dovlyatshina (Kurnakov Inst. of General and Inorganic Chemistry, Academy of Sciences, USSR). Zh. Strukt. Khim., 5: 281-7(Mar.-Apr. 1964). (In Russian)

Measurements of magnetic susceptibility of 44 compounds of Re(VI), Re(V), Re(IV), Re(III), Re(II), and Re(I) showed that most of the compounds are weak para- or diamagnetics. The magnetic properties are interpreted as the tendency of rhenium to form large numbers of bonds, in some cases forming ordinary or multiple rhenium-rhenium bonds. (tr-auth)

**27467** PROTON RESONANCE IN URANIUM PEROXIDE HYDRATES. S. P. Gabuda, Yu. V. Garinskii, S. A. Duransova, and A. G. Lundin (Inst. of Physics, Academy of Sciences, Siberian SSR and Inst. of Inorganic Chemistry, Novosibirsk USSR). Zh. Strukt. Khim., 5: 303-5 (Mar.-Apr. 1964). (In Russian)

The proton resonance method was used for determining the position of protons and the nature of water in $UO_4 \cdot 4.4\ H_2O$ and $UO_4 \cdot 2\ H_2O$. The proton magnetic resonance spectra were measured with a spectrometer at 290 to 90°K (and for the tetrahydrate at 315, 330, and 345°K). The shape of the spectra for both materials seemed to be identical but the tetrahydrate spectra were wider during the transition from 90 to 290°K. It was found that the tetrahydrate spectra at 90°K are a sum of two components: the wide one which was produced by paired protons of crystallized water molecules and the narrow produced by comparatively isolated protons of the OH or OOH group. The relative intensity of the wide component of the tetrahydrate spectra is 95.3 ± 0.4% and of the narrow 4.7 ± 0.4%. The variability of tetrahydrate spectra at 90 to 290°K is related to the increased mobility of water and possibly of the OH and OOH groups. The magnetic resonance method does not determine whether the specimen has a two-phase system consisting of crystal hydrate and some other compound with protons containing OH and OOH groups or a one-phase system of crystallized water with OH and OOH. (R.V.J.)

**27468** PRODUCTION OF COMPOUNDS OF THE RARE EARTH ELEMENTS BY HYDROCHEMICAL METHODS. Yu. B. Perkovskaya, N. P. Anoshina, and I. M. Sukhanova. p.27-30 of "Promyshlennost' Khimicheskikh Reaktivov i Osobo Chistykh Veshchestv." Moscow, 1963.

General methods of producing compounds of the rare earth elements are described. Water-soluble salts (chlorides, bromides, iodides, nitrates, sulfates, and acetates) are produced by direct decomposition of the rare earth oxide or carbonate with a suitable acid and evaporation of the salt solution to dryness. The yield of metal in the finished product is 94 to 96%. Sparingly water-soluble salts (carbonates and oxalates) are produced by decomposing the rare earth oxide with hydrochloric acid and treating the solution with a suitable precipitant (ammonium carbonate or oxalic acid), followed by washing the salt free of the chloride ion. Yield of metal in the finished product is 94 to 97%. A method was developed for producing fluorides of the rare earth elements by sintering the rare earth oxide with ammonium fluoride, used in a double excess in comparison with the stoichiometric amount. Yield of metal in the finished product is 98%. Improved working conditions and a reduction of the technological cycle are cited as advantages of the replacement of hydrofluoric acid by ammonium fluoride. The general properties of rare earth salts are described and the specific optical properties of five rare earth fluorides are cited. (OTS)

**27469** PRODUCTION OF ESPECIALLY PURE SALTS OF LITHIUM AND CESIUM. R. M. Shklovskaya and I. M. Sukhanova. p.61-6 of "Promyshlennost' Khimicheskikh Reaktivov i Osobo Chistykh Veshchestv." Moscow, 1963.

A method based on the complex formation of impurities of iron and heavy metals with sodium diethyldithiocarbamate, followed by sorption of the complexes formed with activated charcoal, was introduced for purifying soluble salts of the alkali metals of impurities of iron and heavy metals to produce high-quality products. This method was found to be cheap, technologically simple, and yielding a high degree of purification. A method of repeated recrystallization of cesium nitrate was introduced into industrial practice for purifying cesium salts from alkali metal impurities. This method provides for the production of high-purity cesium salts, containing no more than 0.001 to 0.002% alkali metal impurities. A method including fractional crystallization of rubidium sulfate was introduced for producing high-purity rubidium salts, containing no more than 0.005% cesium. An industrial method for purifying rubidium of potassium impurities was announced as in the development stage. (OTS)

**27470** THE SOLUBILITY OF HYDROGEN IN LIQUID SODIUM. David Warren McClure. Thesis, Seattle, Univ. of Washington, 1963. 111p.

An apparatus was constructed for studying the solubility of hydrogen and deuterium in liquid sodium at low concentrations in the temperature range 263–350°C. The solubilities were found to obey Henry's Law over the entire concentration range below the phase transition. As a consequence, the proposition that dissociation is the primary step in the solution process is clearly substantiated. The heat of solution in the P¼ region was calculated. A theoretical calculation of the heat of solution was made for two possible solute species; the hydrogen atom and the hydride

ion. It was shown that the existence of the atom was extremely unlikely. From the poor correlation between experiment and theory for the case of the hydride ion, it was concluded that a model based on a purely ionic field is not a good approximation for the present case of a dilute mixture. (Dissertation Abstr., 24: No. 11, 1964)

**27471** PRECIPITATION OF COLUMBIUM OXIDE FROM A SUPERSATURATED COLUMBIUM–OXYGEN SOLID SOLUTION. Lester Joseph Regitz. Thesis, Troy, N. Y., Rensselaer Polytechnic Inst., 1962. 108p.

Solid solutions of oxygen in Nb were prepared at 1250°C, cooled rapidly to retain all the oxygen in supersaturated solution, and subjected to isothermal precipitation heat treatments at 650 and 705°C, in a high vacuum. The course of precipitation was followed through measurement of the lattice parameter of the matrix and, in some specimens, microhardness measurements. The morphology of the precipitate was determined metallographically. At 650°C, equiaxed NbO precipitate particles were nucleated at the intersections of grain boundaries with free surfaces. At 705°C, in addition to these sites, particles nucleated at grain boundaries and grain boundary intersections throughout the matrix. In all cases, growth of the precipitate was continuous, in that an equilibrium oxygen concentration was approached, by the matrix, without the formation of metastable intermediate solutions or precipitates. The rate of decomposition was strongly dependent on the supersaturation of the solid solution. In specimens supersaturated 1.50 at.% decomposition was first detected after 2 hours at 650°C and after 0.5 hours at 705°C. Decomposition was essentially complete after 8 hours at 650°C and after 40 hours at 705°C. Specimens 0.85 at. % supersaturated began to decompose after 20 hours at 650°C and after 10 hours at 705°C. At this degree of supersaturation decomposition was not complete at either 650 or 705°C within 100 hours, which was the longest period of precipitation heat treatment used in this investigation. Analysis of the time dependence of the precipitation process indicated that the process was controlled by the reaction rate at the growing particles surface, and not by diffusion of oxygen through the matrix. In confirmation of this, the analysis of the temperature dependence yielded an experimental activation energy for precipitation that was much greater than that for the diffusion of oxygen through Nb. This activation energy was found to be highly concentration dependent. (Dissertation Abstr., 24: No. 11, 1964)

**27472** I. KINETICS AND MECHANISM OF THE REACTION OF $UO_2(NO_3)_2 \cdot N_2O \cdot H_2O$ WITH 2,4 DICHLOROANILINE IN ALCOHOLIC SOLUTIONS. II. A NEW REACTION CALORIMETER UTILIZING THERMOELECTRIC HEAT PUMPING UNDER ISOTHERMAL CONDITIONS. Kenneth Ward Edwards. Thesis, Boulder Colo., Univ. of Colorado, 1963. 127p.

I. The reaction between $UO_2(NO_3)_2 \cdot N_2O_4 \cdot H_2O$ and 2,4 dichloroaniline to form bis(2,4 dichlorophenyl) triazene has been studied in ethanol and n-butyl alcohol. The uranyl-$N_2O_4$ complex reacts with the alcohols to form alkyl nitrites. A mechanism is proposed in which nitrosonium ion ($NO^+$) from the alkyl nitrite reacts with a molecule of amine followed by loss of water to yield a diazonium ion. The latter N-couples with a second molecule of amine to yield the product triazene. The reaction is catalyzed by hydrogen ion. The overall reaction was found to obey the kinetic expression: rate = (RONO) $(H^+)$ $(amine)^{0.67}$ under the conditions of the investigation. II. A small isothermal calorimeter that utilizes Peltier (thermoelectric) cooling to compensate the heat liberated by exothermic liquid-phase chemical reactions was designed and built. Reactions are carried out in a gold plated cylindrical reaction chamber, of about 25 ml capacity, in an approximately cubic copper block. Heat generated by chemical reactions is pumped from the calorimeter block by commercially available thermoelectric coolers into a constant temperature environment at such a rate that the temperature gradient between the reaction chamber and the constant temperature bath remains very nearly zero. Temperature fluctuations during the course of a run are held to less than 0.04°C and may be 0.001°, or less, depending on the quantity of heat released and the rate of reaction. Current to the coolers is pulsed and may be varied over a wide range depending on the cooling rate required by the reaction. Heat effects in the range 2 to 200 calories were measured with an average deviation of about 2%. (Dissertation Abstr., 24: No. 11, 1964)

**27473** PARAMAGNETIC RESONANCE BELOW 1°K: SPIN-LATTICE RELAXATION OF TRIVALENT CERIUM AND NEODYMIUM IONS IN LANTHANUM MAGNESIUM NITRATE. Ronald Henry Ruby. Thesis, Berkeley, Calif., Univ. of California, 1962. 104p.

An adiabatic demagnetization cryostat is described for general paramagnetic resonance experiments at a frequency of 9.6 kMcps and at temperatures in the range $0.25 < T < 4.2$°K. The problems of thermal contact were examined and experimental techniques are discussed. The spin-lattice relaxation times of trivalent cerium and neodymium ions in lanthanum magnesium nitrate (LaMN) were measured in the temperature range $0.25 < T < 4.2$°K. The direct spin-lattice relaxation was observed in neodymium and the phonon bottleneck was observed in cerium. Spin-lattice relaxation measurements of trivalent uranium ions in calcium fluoride ($CaF_2$) indicate that in this case spin-lattice relaxation is not being observed, but rather some form of cross-relaxation. (Dissertation Abstr., 24: No. 11, 1964)

**27474** THE EFFECT OF COLLAPSE-INDUCING CATIONS ON THE CESIUM SORPTION PROPERTIES OF HYDROBIOTITE. D. G. Jacobs (Oak Ridge National Lab., Tenn.). p.239-48 of "International Clay Conference, 1963." Pergamon Press, New York, 1963.

The Cs exchange properties of hydrobiotite were improved by collapsing the vermiculite lattices with ammonium ions or with one of the heavy alkali metal cations. Pretreatment with K increased the number of exchange sites at the edges of collapsed basal spacings, where Cs can be incorporated into the lattice by edge fixation. This increased the partial Cs capacity by a factor of 2.7. Addition of $NH_4^+$, $Cs^+$, $Rb^+$, or $K^+$ to the influent resulted in interlayer fixation of Cs as a result of collapse of the lattice to physically entrap the Cs sorbed at the basal surface exchange sites. (auth)

**27475** TECHNIQUE OF INORGANIC CHEMISTRY. VOLUME III. Hans B. Jonassen and Arnold Weissberger, eds. New York, Interscience Publishers, 1963. 350p. $11.50.

Information is included on: gas chromatography; electron microscopy; technique of handling highly active $\beta$- and $\gamma$-emitting material; and glove box techniques. The last two chapters were abstracted separately in NSA. (P.C.H.)

*For abstracts of individual chapters see: 27746 and 27747.*

**27476** WATER DEOXYGENATION BY ION EXCHANGE. C. R. Schmitt (Oak Ridge National Lab., Tenn.). Houston,

Tex., National Association of Corrosion Engineers, 1964. Preprint 78. 7p. (CONF-492-6)

From National Association of Corrosion Engineers, Chicago, Mar. 1964.

Studies were made on the use of a copper-amine ion exchange resin to remove dissolved oxygen from demineralized water in a closed recirculating water system used for cooling research equipment for controlled thermonuclear experiments. A bypass purification system employing honeycomb filters, mixed-bed demineralizers, and a copper-amine resin deoxygenation column is used for removing all contaminants. Another ion exchange method for the removal of dissolved oxygen from water is a conventional strongly basic anion exchange resin in the sulfite form. A laboratory comparison of the oxygen-removing capacity and other performance showed the copper-amine resin to be slightly superior. However, the copper-amine resin showed also several serious disadvantages, which are listed. (P.C.H.)

## Organic Chemistry

**27477** SYNTHESIS OF 1-$^{14}$C-LABELED POLYENE FATTY ACIDS. W. Stoffel and E. Bierwirth (Universität, Cologne). Angew. Chem., 74: 905(Nov. 21, 1962). (In German)

In the course of investigations on the mechanism of biosynthesis of highly unsaturated fatty acids, a generally applicable scheme for total synthesis of polyene acids with $^{14}$C-labeled carboxyl group was developed. This route was applied to the synthesis of 1-$^{14}$C-all cis-octadeca-9,12-dienoic acid (linoleic acid), 1-$^{14}$C-all cis-octadeca-6,9,12-trienoic acid (γ-linolenic acid), and 1-$^{14}$C-all cis-eicosa-5,8,11,14-tetraenoic acid (arachidonic acid). The methyl esters were prepared in a four-step synthesis; the chain was made by coupling a polyene bromide, $CH_3(CH_2)_4(C \equiv CCH_2)_nBr$, with a Grignard of a bromoacetylene, $BrMgC \equiv C(CH_2)_xCl$, in tetrahydrofuran in the presence of Cu(I)CN. The polyene product was then reduced to the all-cis polyene by hydrogenation with a Lindlar catalyst. The terminal chloride was next displaced by $Na^{14}CN$ in dimethyl sulfoxide in yields above 90%. Acid-catalyzed saponification of the nitrile in methanol yielded the methyl ester of the fatty acid, again in yields above 90%. The purity of the intermediates was determined by gas chromatography, hydrogen number, ultraviolet and infrared spectroscopy, and alkali isomerization. Methods of purification (mostly short-path distillation or preparative gas chromatography), boiling points, and refractive indexes are tabulated for all of the new intermediates. (BBB)

**27478** SYNTHESIS OF DL-4-AMINO-3-HYDROXY-BUTYRIC ACID-[CARBOXY-$^{14}$C], DL-CARNITINE-[CARBOXY-$^{14}$C] AND (-)-CARNITINE-[METHYL-$^{14}$C]. Sven Lindstedt and Goran Lindstedt (Karolinska Institutet, Stockholm). Arkiv Kemi, 22: 93-6(1964).

To synthesize carnitine in good yields a route involving 3-hydroxy-4-aminobutyric acid appeared suitable since it should make it possible to prepare carnitine labeled in the methyl as well as in the carboxyl group and since methylation of the optically active amino acid should provide (-)-carnitine in high isotopic yield. The resolution of 3-hydroxy-4-aminobutyric acid was achieved by a modified procedure in which 3-hydroxy-4-benzamidobutyric acid was resolved via the strychnine and brucine salts. The syntheses and yields based on radioactivity are described. (TCO)

**27479** THE 3820 Å BAND SYSTEM OF PROPYNAL. J. C. D. Brand, J. H. Callomon, and J. K. G. Watson (Glasgow Univ. and London Univ.). Discussions Faraday Soc., No. 35, 175-83(1963).

The first singlet-singlet $\pi^* - n$ transition of gaseous propynal, $C_2H \cdot CHO$, gives rise to a band-system in absorption centered near 3820 Å. The rotational and vibrational structures of this spectrum, together with that of the deuterated isotopes $C_2H \cdot CDO$ and $C_2D \cdot CHO$, were extensively analyzed. Of the 12 excited-state fundamental frequencies, all but one were assigned and measured. Rotational analysis reveals a small positive inertial defect in the excited state, as in the (planar) ground state, and it is concluded that the excited state is also planar. All non-totally symmetric vibrations appear in the spectrum, but only in very short progressions; this fact is attributed to intensity stealing. Several of the numerous Fermi and Coriolis couplings that are observed were analyzed. The excited-state vibrational frequencies show that the effects of electronic excitation are not limited to the carbonyl chromophore, but also transmitted to the furthest atoms in the acetylenic chain. (auth)

**27480** THE SPECIFICITY OF THE ELECTRON-IMPACT INDUCED ELIMINATION OF WATER FROM ALCOHOLS AND RELATED REACTIONS IN THE MASS SPECTROMETER. Wolfgang Benz and K. Biemann (Massachusetts Inst. of Tech., Cambridge). J. Am. Chem. Soc., 86: 2375-8(June 20, 1964).

A series of aliphatic alcohols (n-butyl through n-heptyl) with a $CD_2$ group in consecutive positions (C-1 through C-5 from the hydroxyl group was synthesized. Their mass spectra indicate that the elimination of the elements of water, which leads to the $(M-18)^+$ ion in the undeuterated alcohols, involves almost exclusively (ca 90%) a H atom at C-4, the remainder coming from C-3 and C-5. The elimination of water from fragment ions of tertiary alcohols is less specific. The loss of acetic acid from n-alkyl acetates (to give a peak at M − 60) involves the hydrogens at C-2 and C-3 (to about 55 and 45%, respectively). The additional H required for the formation of the ion of mass 61 ($CH_3COOH_2^+$) seems to be abstracted rather unspecifically from all other carbons of the alkyl chain of the alcohol moiety. (auth)

**27481** TUNNELING IN A PROTON TRANSFER. A LARGE ISOTOPE EFFECT. Lance Funderburk and Edward S. Lewis (Rice Univ., Houston, Tex.). J. Am. Chem. Soc., 86: 2531-2(June 20, 1964).

Isotope effects, including those arising from effects of impurities (including acetone) in nitro compounds, pyridine bases, and the solvent and from nonreproducibility in solvent composition, uncertainties in temperature, extinction coefficients, and time were searched for gross errors, but none were found. The temperature dependence of the isotope effect for the reaction with 2,4,6-collidine fits the equation $k_H/k_D = 0.146e\ 3030/RT$, where the small pre-exponential factor ratio indicates tunneling, as does the 3 kcal difference in activation energy, which is inconceivably large for any difference in loss of zero-point energy. The presence of a large tunnel correction is demonstrated. It was concluded that slow sterically hindered H transfer reactions in other cases may also show extremely large isotope effects, and that tunneling may prove to be more common than was believed. (P.C.H.)

**27482** ELECTRON SPIN RESONANCE STUDY OF THE PAIRING THEOREM FOR ALTERNANT HYDROCARBONS: $^{13}$C SPLITTINGS IN THE ANTHRACENE POSITIVE AND NEGATIVE IONS. James R. Bolton and George K. Fraenkel (Columbia Univ., New York). J. Chem. Phys., 40: 3307-20 (June 1, 1964).

The pairing theorem for alternant hydrocarbons predicts that the pi-electron spin densities at corresponding positions of the negative and positive ions of a hydrocarbon should be the same, but significant differences have been found previously for the proton hyperfine splittings in electron-spin resonance spectra. The validity of the theorem was examined more thoroughly by measuring the $^{13}C$ splittings in the ESR spectra of the anthracene negative and positive ions. These were obtained by studying the satellites arising from $^{13}C$ nuclei present in natural abundance and also by investigating anthracene labeled with 50% $^{13}C$ in the 9-position. All of the four possible splittings were determined for the negative ion and assigned to the appropriate positions in the radical, and three of the splittings were obtained for the positive ion. The assignments of the splittings and their signs were established by linewidth studies, counter-ion effects, and calculation. The negative ions were produced by reduction with Li, Na, and K, and also electrolytically. An apparatus for the electrolytic generation of radicals in vacuo is described. The positive ions were formed in concentrated sulfuric acid. The $^{13}C$ splittings in the positive and negative ions of anthracene were found to be almost identical. This result is most readily interpreted as implying that the pairing theorem is valid to a high degree of approximation for the spin densities and for those of the sigma-pi parameters which govern the $^{13}C$ splittings. (auth)

**27483** SECONDARY ISOTOPE EFFECTS IN THE CHEMICALLY ACTIVATED sec-BUTYL-$d_0$ AND -$d_8$ SYSTEMS AND sec-BUTYL-$d_1$ AND -$d_9$ SYSTEMS. J. W. Simons, B. S. Rabinovitch, and R. F. Kubin (Univ. of Washington, Seattle). J. Chem. Phys., 40: 3343-51(June 1, 1964).

The decomposition of chemically activated sec-butyl-$d_8$ and -$d_0$ radicals, produced by H- and D-atom addition to cis-butene-2-$d_8$, was studied at 195 and 300°K over a range of pressures. These measurements, as well as internal comparison experiments with cis-butene-2-$d_0$, reveal a large normal secondary intermolecular kinetic-isotope ratio which varies with the pressure and temperature, and the minimum value of which is a factor of 4, while the maximum value averages around 7. The absolute magnitude of the ratio, and its temperature, pressure, and energy dependence are in satisfactory agreement with the theory of these chemical-activation systems; some aspects of this dependence are discussed. Evidence against a significant mechanistic isotope effect on the energetics is presented. Calculated isotope effects for all of the possible sec-butyl radical systems, to be formed by H- and D-atom addition to butene-$d_0$ and -$d_8$ isomers, are given. (auth)

**27484** DECARBOXYLATION AND DEUTERIUM EXCHANGE IN SOME AZABICYCLIC KETONE SYSTEMS. Herbert O. House and Hanspeter C. Mueller (Massachusetts Inst. of Tech., Cambridge). J. Org. Chem., 27: 4436-9(Dec. 1962).

Synthetic studies of bicyclo[3,2,1]-3-azaoctan-8-one and its homologs showed that boiling 20% HCl effects hydrolysis and decarboxylation of the corresponding bridgehead ester to produce the ketone in 60–70% yield. The same reaction using 20% DCl in $D_2O$ forms the deuterated ketone. These conditions gave no reaction when applied to bicyclo [3,3,1]-1-carboxynonan-9-one, and the diacid was generated from 3-methyl-1,5-dicarboethoxy[3,2,1]-3-azaoctan-8-one. This information suggested that enol formation at the bridgehead in the bicyclo[3,3,1]nonane system has a borderline possibility. The normal decarboxylation path is incorrect in these cases. To determine the ease of formation of bridgehead enols in these cases, the ketones were heated with 20% DCl in $D_2O$. The usual statistical incorporation of deuterium was not observed; the relative rates at which the ketones incorporate D increases with increasing strain (bicyclo[3,2,1]azaoctanone > bicyclo[3,3,1]azanonanone > bicyclo[4,3,1]azadecanone), and all of the deuterated compounds contain two D's per molecule. Thus a bicyclic intermediate enol is incompatible with experimental results; several monocyclic intermediates are considered. One of these is the Mannich reaction intermediate that occurs in the synthesis of the azabicyclic ketones; this suggests that the cyclization in the synthesis is clean. On the basis of this a new mechanism is proposed for the decarboxylation of the bridgehead esters. (BBB)

**27485** RATE CONSTANTS OF HYDRATED ELECTRON REACTIONS WITH ORGANIC COMPOUNDS. Edwin J. Hart, Sheffield Gordon, and J. K. Thomas (Argonne National Lab., Ill.). J. Phys. Chem., 68: 1271-4(June 1964).

The second-order rate constants of reaction of some aliphatic, aromatic, and heterocyclic compounds with the hydrated electron are reported. These constants were measured in unbuffered and in alkaline solutions by following the decay of the hydrated electron absorption band produced by a single 0.2- or 0.4-μsec pulse of 15 Mev electrons. Unreactive compounds with second-order rate constants less than $10^8$ $M^{-1}$ $sec^{-1}$ include saturated organic compounds containing carbon, hydrogen, and oxygen. Representative compounds are hydrocarbons, alcohols, fatty acids, esters, and amino acids. Unreactive also are unsaturated compounds including aromatic derivatives such as ethylene, benzene, aniline, and hydroquinone. Reactive compounds with rate constants in the range of $10^9$ to $3 \times 10^{10}$ $M^{-1}$ $sec^{-1}$ are: unhydrated aldehydes, ketones, compounds containing C=C or C≡N, disulfides, peroxides, and purine and pyrimidine heterocyclic derivatives. (auth)

**27486** SECONDARY INTERMOLECULAR KINETIC ISOTOPE EFFECTS IN THE METHYLENE RADICAL-cis-BUTENE-2-$d_8$-cis-1,2-DIMETHYLCYCLOPROPANE-$d_8$ SYSTEM. J. W. Simons and B. S. Rabinovitch (Univ. of Washington, Seattle). J. Phys. Chem., 68: 1322-35(June 1964).

A study of the geometric and structural isomerization reactions of chemically activated cis-1,2-dimethylcyclopropane-$d_0$ (DMC-$d_0$) and DMC-$d_8$ is reported. Activation was by addition of methylene, from the photolysis of ketene at 3200 Å and 25°, to the double bond of cis-butene-2-$d_0$ and -$d_8$. The measured intermolecular isotope effects for the geometric isomerization ($k_g(H)/k_g(D)$ = 3.8) and for one of the structural isomerization ($k_{sp}(H)/k_{sp}(D)$ = 4.3) reactions are, for the most part, secondary quantum statistical-weight effects. The effect on other structural isomerization processes ($k_{sb}(H)/k_{sb}(D)$ = 5.2) is a mixed primary-secondary isotope effect. Theoretical calculations of rates and of isotope effects are in fairly good agreement with experimental values. Anomalous high-pressure product compositions in both the -$d_0$ and -$d_8$ systems can be explained by the presence of ~29% triplet methylene radical reaction at high pressures. The addition of oxygen altered the product composition so as to indicate the removal of such triplet methylene reaction. Earlier work on the isotope effects in singlet methylene radical C–H insertion and C=C addition reactions with cis-butene-2 was extended. Calculations of the geometric isomerization rates of 1,2-cyclopropane-$d_2$ and 1,2-dimethylcyclopropane were made and are compared to the existing data in thermal and chemical activation systems. (auth)

**27487** MERCURY-PHOTOSENSITIZED DECOMPOSITION OF PROPANE, ISOBUTANE, AND n-PENTANE AT 1849 Å. Richard A. Holroyd and Timonthy E. Pierce (Mellon Inst., Pittsburgh). J. Phys. Chem., 68: 1392-8(June 1964). (RRL-123)

The relative radical yields from the reaction of excited mercury ($^1P_1$) atoms (produced by the 1849-Å line of Hg) with propane, isobutane, and n-pentane have been determined by use of the ethyl-$^{14}C$ radical scavenger. The 1849-Å line was isolated with a preirradiated (with $\gamma$ rays) LiF filter. The primary dissociation of propane by Hg($^1P_1$) atoms yields 50% n-propyl and 50% isopropyl radicals. Similarly the dissociation of isobutane yields 42% isobutyl and 58% t-butyl radicals, and the dissociation of n-pentane yields 28% n-pentyl, 43% 1-methylbutyl, and 29% 1-ethylpropyl radicals. Carbon–carbon bonds are not dissociated at this wave length. The relative rates of removal of tertiary, secondary, and primary hydrogen atoms by Hg($^1P_1$) atoms are in the ratio 12:3:1 contrasting with sensitization of hydrocarbons by Hg($^3P_1$) atoms for which this ratio is 350:65:1. The mechanism of quenching of Hg($^1P_1$) atoms by aliphatic hydrocarbons is formation of radicals by the direct interaction with, and cleavage of, a carbon–hydrogen bond. The ratios, D/R, of disproportionation (in which $C_2H_6$ and an olefin are formed) to combination are estimated: for $C_2H_5$ + n-$C_3H_7$ →, D/R = 0.06; for $C_2H_5$ + i-$C_4H_9$ →, D/R ~ 0; for $C_2H_5$ + n-$C_5H_{11}$, D/R = 0.08. (auth)

**27488** THE RATES OF REACTION OF THE HYDRATED ELECTRON IN AQUEOUS INORGANIC SOLUTIONS. J. K. Thomas, Sheffield Gordon, and Edwin J. Hart (Argonne National Lab., Ill.). J. Phys. Chem., 68: 1524-7(June 1964).

The pulsed radiolysis technique was used to follow the rate of decay of the hydrated electron in the presence of inorganic compounds. The exact technique is described together with the absolute rate constants for these reactions. The activation energy for the reaction of the hydrated electron with $H_3O^+$ was measured as 3.2 kcal/mole and is close to that expected for a diffusion-controlled reaction, while the activation energy for the reaction, $e^-_{aq}$ + $H_2O$, was 4.6 kcal/mole. (auth)

**27489** DEUTERIUM ISOTOPE EFFECT IN THE IONIZATION OF SUBSTITUTED SUCCINIC ACIDS IN WATER AND IN DEUTERIUM OXIDE. Paul K. Glasoe (Wittenberg Univ., Springfield, Ohio) and Lennart Eberson. J. Phys. Chem., 68: 1560-2(June 1964).

An investigation was conducted to see whether the ionization constants of substituted succinic acids would show an abnormal deuterium isotope effect ($pK_D - pK_H > 0.5$) similar to maleic acid. The succinic acids studied were tetramethyl-, tetraethyl-, and rac-α,α′-di-t-butylsuccinic acid and their monomethyl esters. Tetramethyl- and tetraethylsuccinic acid show abnormal $pK_D - pK_H$ differences, while di-t-butylsuccinic acid and the monomethyl esters show normal deuterium effects. (D.L.C.)

**27490** DEUTERIUM ISOTOPE EFFECT IN THE IONIZATION OF SUBSTITUTED MALONIC ACIDS IN WATER AND IN DEUTERIUM OXIDE. Paul K. Glasoe and James R. Hutchison (Wittenberg Univ., Springfield, Ohio). J. Phys. Chem., 68: 1562-3(June 1964).

Ionization constants in $H_2O$ and $D_2O$ were measured for a series of substituted malonic acids. The malonic acids studied were malonic acid, ethyl-, isopropyl-, phenyl-, diethyl-, ethylisopropyl-, and dibutylmalonic acid, and the monoesters of malonic acid, ethyl-, diethyl-, and ethylisopropylmalonic acid. The results indicate that some effect other than H bonding must play an important role in the deuterium isotope effect. (D.L.C.)

**27491** TRITIUM-LABELLING OF NATURAL PRODUCTS. Rainer Maurer, Martin Wenzel, and Peter Karlson (Universität, Berlin and Universität, Munich). Nature, 202: 896-8(May 30, 1964).

A charcoal adsorption method for exposing substances to tritium gas was combined with a platinum catalyst to obtain higher specific activities in nonaromatics without a parallel increase in radiochemical by-products. The steroid digitogenin, which was obtained after 4-hour hydrolysis of digitonin in 4 N hydrochloric acid followed by crystallization from methanol, was tested chromatographically for purity. The charcoal surface area and catalysis effects on effective tritiation are discussed. (R.E.U.)

## Radiation Chemistry and Radiochemistry

**27492** (GNEC-336) INVESTIGATION OF CATALYTIC RECOMBINATION OF RADIOLYTIC OXYGEN AND HYDROGEN. Quarterly Progress Report No. 2, January–March 1964. Gilbert M. Brown, George E. Panter, and C. Thomas Sawyer (General Nuclear Engineering Corp., Dunedin, Fla.). Apr. 10, 1964. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(40-1)-3151. 88p. (EURAEC-1052)

Four commercial catalysts were performance tested; these were labeled "C" through "F". Catalyst "C" is typical of an all-metal material while the others are typical of the alumina materials. Each contained Pt-group elements as the catalytic agent. Data from these short-term tests indicate that catalysts may be used to reduce radiolytic gas concentrations in superheated steam from the parts per million range to the parts per billion range. The tests were performed by passing $O_2$- and $H_2$-laden steam over a specific bed of catalytic material. The steam purity, before addition of the two gases, was typical of conventional power plant boiler quality. Twenty-five ppm of free $O_2$ and a slightly greater than stoichiometric amount of $H_2$ were added to achieve gas concentrations comparable to those found in steam produced by nuclear boilers. The resulting data enabled the development of performance equations for each of these catalysts. It was found that, for Catalysts "C" through "F", the reduction in gas concentration (O) versus bed depth (X), can be defined by the relationship, $-(dO/dX) = (A_r T^a W^b P^c)(O_x)$, where $A_r$, a, b, and c = constants for a given catalyst; $O_x$ = concentration of either $H_2$ or $O_2$ at bed depth "X"; T = absolute temperature; W = steam flow rate for a given bed face area; P = absolute pressure system. For a given catalyst and a specific set of conditions, the term $(A_r T^a W^b P^c)$ is a constant and the relationship $-(dO/dX) = A\,O_x$ is satisfactorily descriptive. It was concluded that only a small amount of catalytic activity exists under wet steam conditions. However, no specific amount of steam superheat is required to obtain significant activity, only dryness. It was also concluded that the efficiency of each catalyst increases with increased temperatures, but decreases with increased steam velocities. There is no theoretical limit to possible gas concentration reductions. A reduction to the parts per billion range is certainly feasible. (auth)

**27493** (RRL-143) RADICAL YIELDS IN THE RADIOLYSIS OF UNSATURATED HYDROCARBONS. R. A. Holroyd and G. W. Klein (Mellon Inst. Radiation Research Labs., Pittsburgh). June 3, 1964. Contract AT (30-1)-2310. 30p.

A radical sampling technique utilizing carbon-14-labeled methyl radicals is applied to the determination of the individual radical yields in the radiolysis of several olefins. The major radicals and yields for propylene are, allyl (44%), isopropyl (34%), and n-propyl (12%). In 1-butene the major radicals and corresponding yields are, 1-methylallyl (42%), 3-butenyl (6%), sec-butyl (25%), and n-butyl (11.5%) showing that the loss of an allylic hydrogen atom occurs 11 times more readily than loss of a primary hydrogen atom. The 1-methylallyl radicals observed from trans-2-butene are 96% in the trans configuration, $CH_3 \diagdown CH \cdots CH \cdots CH_2$, whereas from cis-2-butene 80% are in the cis configuration, $CH_3 \diagdown CH \cdots CH \cdots CH_2$. This retention of structure suggests that a low energy process (e.g., abstraction of a hydrogen atom) is responsible for formation of allylic radicals. Approximately two-thirds of the combinations of methyl with 1-methylallyl radicals occur at the terminal carbon atom. The major radical species found in isobutene is 2-methylallyl. The precursor of the n-propyl radicals from propylene, the n-butyl radicals from 1-butene, and >60% of the sec-butyl radicals observed in cis-2-butene is not a thermal hydrogen atom. The effect of $^{14}CH_3I$ concentration on the relative radical yields suggests that the major source of $^{14}CH_3$ radicals is not abstraction of iodine atoms from $^{14}CH_3I$ by thermal hydrogen atoms. (auth)

**27494** (TID-19197) COMMENTS ON THE MECHANISM OF THE RADIATION DECOMPOSITION OF AQUEOUS AZIDE SOLUTION CONTAINING MERCURIC SALTS. M. Lee Hyder (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). [July 1963]. Contract AT (07-2)-1. 3p.

It is suggested that the high yields of radiation products in an aqueous solution of mercuric and azide ions, may be due to the action of subexcitation electrons on a mercuric-azide ion complex. This suggestion is supported by the fact that the addition of mercuric ions to an azide solution produces a strong optical absorption band below 3000 A up to 3500 A, indicating both the formation of a complex and the possibility of its excitation by electrons which can no longer excite water molecules. (D.L.C.)

**27495** (TID-19357) THE COBALT-60 GAMMA-RAY INDUCED DESTRUCTION OF THE PORPHYRIN RING STRUCTURE. Mary-Louise Rothschild and L. S. Myers, Jr. (California. Univ., Los Angeles. School of Medicine. Lab. of Nuclear Medicine and Radiation Biology). [July 16, 1963]. Contract AT(04-1)-Gen-12. 6p.

Studies were made of the mechanism of the ring destruction reaction in the gamma radiolysis of ferriprotoporphyrin (FPP) in alkaline solutions. The reaction induced by $H_2O_2$ was also studied, and the results indicate that $H_2O_2$ is not the radiolytic product which destroys the porphyrin ring. The effects of various solutes on the radiolysis of FPP were determined. The ring destruction reaction was inhibited in air-free NaOH, aerated carbonate-bicarbonate buffered, unbuffered nitrate, and other solutions, indicating that it is due to reactions involving both H (or $H_2O^-$) and $O_2$. (D.L.C.)

**27496** (TID-20713) RADIOLYSIS OF CYCLOPENTANONE. I. STUDIES ON THE $H_2$, CO, AND $C_2H_4$ YIELDS. M. Katayama and C. N. Trumbore (Delaware. Univ., Newark). [1967]. Contract AT(30-1)-953. 27p.

The yields of CO and $H_2$ were measured in the $^{60}Co$ gamma radiolysis of liquid cyclopentanone and in solutions of cyclopentanone containing various additives. G(CO) was found to have an initial value estimated to be about 1.5 but is quickly reduced to less than 0.8 after an absorbed dose of about $10^{20}$ ev/g. $G(H_2) = 0.68$ and is independent of temperature up to 100°C but G(CO) increases at this higher temperature. The ratio of $G(H_2)/G(CO)$ was insensitive to radiation intensity, type radiation (90 kvp x rays vs 1 Mev γ rays), and surface/volume ratio. $G(H_2)$ was reduced by adding $I_2$, DPPH, cyclohexene, and benzene and was unaffected by added ethylene and $CO_2$. G(CO) was slightly increased by the addition of ethylene. The isotopic hydrogen yields from radiolyzed 2,2,5,5-cyclopentanone-$d_4$ are reported. (auth)

**27497** (WAPD-BT-30(p.53-64)) THE IONIZATION OF WATER BY MIXED RADIATION FROM A NUCLEAR REACTOR. Y. Solomon (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh).

The fast neutrons and gamma rays generated in a nuclear reactor create, in a water coolant, a spectrum of energetic protons and electrons. The calculation of the average linear energy transfer (LET) from this spectrum can aid in understanding the phenomenon of radiolytic water decomposition. Equations are derived that permit calculation of a recoil proton energy spectrum from a neutron energy spectrum. The mechanics of using these equations to obtain the proton spectrum from the 54-group neutron spectrum of the P3MG1 calculation are given. (auth)

**27498** INDUCED CONDUCTION AND ION MOBILITY IN SILICONE OILS IONIZED BY X-RAYS. B. Jachym (Technical Univ., Danzig). Acta Phys. Polon., 25: 385-90 (Mar. 1964).

The mobilities of negative and positive ions in silicon oils were measured. The activation energies were determined from the temperature-dependence of the viscosity coefficient and ion mobility, and the respective results were found to differ but slightly. Measurements of the ionization current in OE-4018 oil revealed a value about twice as high as in DC-703 oil and in hydrocarbon liquids. (auth)

**27499** PYRUVATE-$C^{14}$, PURITY AND STABILITY. R. W. Von Korff (Univ. of Minnesota, Minneapolis). Anal. Biochem., 8: 171-8(June 1964).

The frequent presence of $^{14}C$-labeled impurities in commercially available sodium pyruvate-$^{14}C$ and the instability of sodium pyruvate-$^{14}C$ solutions is reported. The presence of multiple impurities, one of which appears to be para-pyruvate, is demonstrated. The latter does not appear to be the major decomposition product in the samples studied. Pyruvic acid-$^{14}C$ liberated from pure sodium pyruvate-$^{14}C$ by the addition of a stoichiometric amount of HCl is stable for at least 3 months if stored at −20°C. (auth)

**27500** ESR INVESTIGATIONS ON IRRADIATED AMINO ACIDS. G. Schoffa (Technische Hochschule, Karlsruhe, Ger.). Biophysik, 1: 297-8(1964). (In German)

Electron spin resonance was used to study free radicals produced by irradiation of amino acids. (M.C.G.)

**27501** SIMULATION OF X-RADIATION EFFECTS BY MEANS OF FREE RADICALS. Friedrich Wilhelm Froben (Universitlt, Göttingen, Ger.). Biophysik, 1: 303-8(1964). (In German)

The $OH^-$ radicals originating in a high-frequency discharge in water vapor caused the oxidation of iron(II) and the reduction of cerium(IV), while H atoms from a hydrogen discharge reduced hexacyanoferrate(III), gold(III), and silver(I). The results were compared with those obtained by x-ray irradiation and the reaction equations are discussed. It was possible to separate the effects of $OH^-$ radicals and H atoms, which always appear jointly in irra-

diation. It was concluded that $OH^-$ radicals are more strongly responsible for the secondary, chemical effects of irradiation than H atoms. (tr-auth)

**27502** THE ROLE OF THE DISULFIDE LINKS IN THE INACTIVATION OF PROTEINS BY RADIATION. Klaus Dose (Max-Planck-Institut fltr Biophysik, Frankfurt am Main). Biophysik, 1: 316-24(1964). (In German)

Radioinduced chemical and physicochemical changes in proteins were studied. Irradiated proteins were analyzed for SH and S-S groups. Results are shown in graph form. (M.C.G.)

**27503** THE RADIOLYSIS OF BIPHENYL BY GAMMA-RAYS. Hiroaki Kōyama, Gen-ichi Tsuchihashi, and Akibumi Danno (Japan Atomic Energy Research Inst., Tokyo). Bull. Chem. Soc. Japan, 37: 478-84(Apr. 1964).

The mechanism of the gamma radiolysis of biphenyl was studied by determining the G-values of the non-volatile products. Different reaction patterns were observed between the liquid and solid states, and G-values were found to be independent of the total absorbed dose in the ranges used. The sums of the G-values for terphenyls and quaterphenyls were 0.0083 and 0.041, respectively; the latter is about 5 times as large as the former. The radiolysis mechanism is discussed and data are tabulated. (P.C.H.)

**27504** THE ANISOTROPY OF THE ESR SPECTRUM OF IRRADIATED POLY($\beta$-PROPIOLACTONE). Shun-ichi Ohnishi, Shun-ichi Sugimoto, Koichiro Hayashi, and Isamu Nitta (Japanese Assn. for Radiation Research on Polymers, Osaka). Bull. Chem. Soc. Japan, 37: 524-7 (Apr. 1964).

The angular variation of the ESR spectrum of irradiated poly($\beta$-propiolactone) was measured. The polymer was obtained by radioinduced solid-state polymerization of a single crystal of the monomer at low temperatures. The radical produced in irradiated poly($\beta$-propiolactone) was assigned to $-CH_2-CH-CO-O-$. The zigzag chain of the radical almost points in the z direction of the sample. In the x and y directions, however, the orientation of the $C-H_\alpha$ and the unpaired $\pi$-axis (the zigzag plane) is almost at random. The average orientation of the $\pi$-axis, although almost random, is nearly parallel to the x-axis ($l = 0.983$, $m = 0.092$, and $n = -0.160$). (P.C.H.)

**27505** THE RADIATION-INDUCED REACTION OF SULFUR IN VARIOUS SOLVENTS. Wataru Ando (Radiation Center of Osaka Prefecture, Sakai), Ken'ichi Sugimoto, and Shigeru Oae. Bull. Chem. Soc. Japan, 37: 582-3(Apr. 1964).

G-values for the formation of various mercaptans and hydrogen in the radiolysis of various hydrocarbon solutions of S such as hexane, cyclohexane, mesitylene, ethylbenzene, p-xylene, toluene, and diphenylmethane, were determined, and the G-value of hydrogen formation was compared with those of the corresponding hydrocarbons with the hope of obtaining some direct information on the effect of hydrocarbons as solvents on the radiolysis of hydrocarbon solutions of S. The data indicate that the G-values of the formations of mercaptans were of similar magnitudes, with only a little difference caused by the differences in the stabilities of the mercaptans formed. The G-values of hydrogen formation in both hexane and cyclohexane solutions of S were appreciably decreased by the presence of S. (P.C.H.)

**27506** FISSION FRAGMENT IRRADIATIONS OF HYDROCARBONS. I. YIELD AND ISOTOPIC COMPOSITION OF HYDROGEN FROM MIXTURES OF CYCLOHEXANE AND BENZENE WITH THEIR DEUTERATED ANALOGUES. A. W. Boyd and H. W. J. Connon (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Chem., 42: 1418-25(June 1964).

Cyclohexane and benzene and mixtures of each of these with cyclohexane-$d_{12}$ and benzene-$d_6$ were irradiated with fission fragments using thin sources of $^{235}U_3O_8$. The hydrogen yield $G(H_2)$ for cyclohexane is 7.73, and is only slightly reduced by the addition of benzene. $G(H_2)$ for benzene is 2.14. The isotopic composition of the hydrogen from the four mixtures indicates that most is formed in bimolecular processes. To correlate the results with those obtained in gamma radiolysis, a mechanism is proposed based on hydrogen formation by reactions between transient species in both cyclohexane and benzene. (auth)

**27507** $\beta$-RADIATION SOURCES ON CELLULOSE ACETATE MATRIX. M. Zaduban (Slowakische Akademie, Wissenschaften, Kosice, Ger.). Collection Czech. Chem. Commun., 29: 1065-8(Apr. 1964). (In German)

Preparation of beta sources by incorporation of a beta-emitting isotope on a cellulose acetate matrix is described. Aqueous solutions of compounds containing $^{32}P$ and $^{35}S$ were mixed with cellulose acetate and the solvent evaporated. Acetone and acetic acid were used as solvents and cellulose acetate amounts up to 1.5 g were used. Properties of these sources were determined. (M.C.G.)

**27508** STUDY OF THE LUMINOUS EMISSION OF VARIOUS SOLIDS IRRADIATED BY AN ELECTRON BEAM. Georges Bisson (Laboratoires de la C.S.F., Corbeville, France). Compt. Rend., 258: 4012-15 (Apr. 20, 1964). (In French)

Fluorescence of $Nd^{3+}$ in crystalline and vitreous systems and the emission of an intense recombination light from GaAs were excited using monoenergetic electron beams of energy up to 35 kv. The spectra and absolute intensity of these luminous emissions were measured as functions of incident electron energy, current density, and target temperature. (tr-auth)

**27509** STUDY OF THE VALENCE STATES OF $As^{77}$ FORMED BY BETA DECAY OF $Ge^{77}$ IN $GeO_2$. Michel Genet and Christiane Ferradini (Institut de Radium, Paris). Compt. Rend., 258: 4525-7(May 4, 1964). (In French)

The $^{77}Ge$ was formed by the reaction $^{76}Ge(n,\gamma)$ in $GeO_2$, which was then dissolved in an alkaline solution. The ions were separated by paper electrophoresis, and the proportions of $^{77}As^{3+}$ and $^{77}As^{5+}$ were determined by measuring the resultant distribution of $\beta^-$ activity. The pH and $As^{3+}$ content of the medium in which the $GeO_2$ was dissolved were determined to affect the results. The effect of dissolved oxygen was also examined. The most representative distribution appears to be 85% $As^{3+}$ and 15% $As^{5+}$. (D.C.W.)

**27510** STUDY OF THE RADIOLYSIS OF PYRIDINE IN THE LIQUID STATE. Francoise Antoine (Faculté des Sciences, Orsay, France). Compt. Rend., 258: 4742-4 (May 11, 1964). (In French)

The effect of $^{60}Co$ gamma rays on pure pyridine at room temperature and in the absence of oxygen was studied. The radical yields were determined using two new stable free radicals as interceptors, and the formation of the radiolysis products—a polymer, hydrogen, gaseous hydrocarbons, and $\alpha,\alpha$-dipyridyl—was studied as a function of dose. The results indicate that pyridine is more sensitive to gamma rays than benzene. (D.C.W.)

**27511** THERMAL ANNEALING REACTIONS IN NEUTRON-IRRADIATED CALCIUM IODATE. S. Kaucic and

M. Vlatković (Institut "Ruder Bošković", Zagreb). Croat. Chem. Acta, 35: 305-13(1963).

Thermal annealing of $^{128}I$ in neutron-irradiated Ca iodate showed the usual increase in the retention as observed earlier with the products of Szilard-Chalmers reactions. A series of systems of Ca iodate with the incorporated impurity $^{131}I$ in the form of $I^-$ was also prepared and the isotopic exchange of $IO_3^-$-($I^-$,$I_2$) was studied at higher temperatures (170 to 400°C). The results are discussed in view of the possibility that isotopic exchange reactions may participate in the processes of the return of the recoil atoms to the chemical form of the target. (auth)

**27512** ELECTRONIC ABSORPTION SPECTRA OF HCO AND DCO RADICALS. J. W. C. Johns, S. H. Priddle, and D. A. Ramsay (National Research Council, Ottawa). Discussions Faraday Soc., No. 35, 90-104(1963).

The long wavelength absorption bands of HCO and DCO were observed with much greater intensity than in earlier work. Rotational and vibrational analyses of 22 new bands were carried out and new molecular constants obtained. The numbering of the bands in the principal progression $(0, v_2', 0)-(0, 0, 0)$ was revised so that the $\Sigma$ vibronic levels now correspond to odd values of the quantum number $v_2'$. Analysis of the rotational envelopes of some of the diffuse bands was carried out. The $\Pi$ bands are found to be staggered to lower frequencies relative to the $\Sigma$ bands and fairly large $\Sigma-\Delta$ and $\Pi-\Phi$ splittings are also found. These splittings are roughly quadratic in K, i.e., $\nu_0^K = \nu_0 - GK^2$, where G ~ 15 $cm^{-1}$ for HCO and ~10 $cm^{-1}$ for DCO. The magnitudes of these splittings are consistent with those calculated from the theory of Pople and Longuet-Higgins assuming that the molecule exhibits a Renner effect. A short discussion of dissociation and predissociation is given. (auth)

**27513** CHEMICAL RADIATION DAMAGE IN CRYSTALLINE POTASSIUM IODATE. S. R. Mohanty (Banaras Hindu Univ., Varanasi, India). Indian J. Chem., 2: 205(May 1964).

It was found that solid potassium iodate is not much susceptible to chemical radiation damage. (auth)

**27514** ELECTRON SPIN RESONANCE IN IRRADIATED GLYCINE CRYSTALS. J. R. Morton (National Research Council, Ottawa). J. Am. Chem. Soc., 86: 2325-9(June 20, 1964). (NRC-7956)

The irradiated glycine crystals enriched with 55% $NH_3^+{}^{13}CH_2CO_2^-$ were studied by electron spin resonance. The two radicals that were formed both exhibited $^{13}C$ hyperfine interaction and are shown to be $NH_3^+CHCO_2^-$ and $CH_2CO_2^{2-}$. The methylene group in $CH_2CO_2^{2-}$ is apparently undergoing hindered rotation about the C–C bond. (auth)

**27515** HYDROGEN TRANSFER AND ENERGY TRANSFER IN THE $\gamma$-RADIOLYSIS OF BENZOPHENONE–2-PROPANOL. EFFECTS OF NAPHTHALENE AND OF PHENYL DISULFIDE. Warren V. Sherman and Saul G. Cohen (U. S. Army Labs., Natick, Mass. and Brandeis Univ., Waltham, Mass.). J. Am. Chem. Soc., 86: 2390-2 (June 20, 1964).

Irradiation of benzophenone in 2-propanol leads to benzpinacol, with rate zero order in benzophenone, and to an equimolar additional quantity of acetone. Naphthalene has essentially no effect in this system, indicating that triplet benzophenone may not be intermediate in the $\gamma$ induced reaction, in contrast to the uv radioinduced reaction. Phenyl disulfide inhibits both light and $\gamma$-induced reductions of benzophenone. The radical $(C_6H_5)_2COH$ is an intermediate for consumption of benzophenone and formation of benzpinacol in both systems. Disulfide and mercaptan protect solvent and solute against radiation by repeated H transfer reactions. (auth)

**27516** THE STEREOCHEMISTRY OF THE REPLACEMENT OF CHLORINE ATOMS IN ALKYL HALIDES BY CHLORINE-38 ACTIVATED IN THE (n,$\gamma$) PROCESS. C. M. Wai, C. T. Ting, and R. S. Rowland (Univ. of Kansas, Lawrence). J. Am. Chem. Soc., 86: 2525-6(June 20, 1964).

The meso and dl forms of 2,3-dichlorobutane were prepared by the low-temperature addition of $Cl_2$ to the cis and trans forms of 2-butene, respectively. Irradiation of meso-2,3-dichlorobutane in the liquid phase at 20°C resulted in the formation of $^{38}Cl$-labeled meso- and dl-2,3-dichlorobutane in the approximate ratio 1.0 : 0.39 ± 0.02. Experiments with dl-2,3-dichlorobutane showed a similar 1.0 : 0.40 ± 0.02 ratio of $^{38}Cl$-labeled target molecule to labeled diastereomer. Both the absolute yields of the labeled diastereomers and their yield ratio were essentially unaffected by the presence or absence of free radical scavengers. When either of the 2,3-dichlorobutanes was irradiated in the gas phase, the $^{38}Cl$ activity was reduced by a factor of 15 to 20 in the irradiated molecule from that observed in the liquid phase, and was zero within the limits of error in the diastereomer. Reasons for this are discussed. (P.C.H.)

**27517** TRITIUM NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY. I. OBSERVATION OF HIGH-RESOLUTION SIGNALS FROM THE METHYL AND METHYLENE GROUPS OF ETHYLBENZENE. THE NONRADIOCHEMICAL USE OF TRITIUM AS A TRACER. G. V. D. Tiers, C. A. Brown, R. A. Jackson, and T. N. Lahr (Minnesota Mining and Mfg. Co., St. Paul). J. Am. Chem. Soc., 86: 2526-7(June 20, 1964).

The high-resolution nmr spectroscopy of tritium in methyl and methylene groups in ethylbenzene was observed. The spectrum consisted of two first-order multiplets, the higher-field one due to the $-CH_2T$ group being apparently a triplet of triplets. The weaker peak, due to the $-CHT-$ group, was less clearly seen but appeared to be a doublet of quadruplets, as would be expected for X in an $A_3BX$ case. Values for coupling constants are given. Thus, the possibility of using the nonradiochemical nmr properties of tritium in chemical studies was demonstrated. (P.C.H.)

**27518** MASS SPECTRAL STUDIES. II. MOLECULAR REARRANGEMENT UNDER ELECTRON IMPACT. P. Funke, K. G. Das, and Ajay K. Bose (Stevens Inst. of Tech., Hoboken, N. J.). J. Am. Chem. Soc., 86: 2527-8 (June 20, 1964).

Molecular rearrangements under electron impact involving the migration of aryl and alkyl groups are reported. A rearrangement involving aryl migration from N to C was discovered. Definitive evidence on aryl migration was obtained when only a peak at m/e = 208 and not at 194 was observed in the spectrum of N,N-diphenyltolylacetamide. Indirect evidence was obtained by deuteration studies on amides. The dideuterated forms of N,N-diphenylphenylacetamide and N,N-ditolylphenylacetamide where the deuterium atoms were in the benzylic position showed very small peaks at m/e = 194 and 208, respectively. The results of spectra of other compounds are also reported, and a mechanism for aryl migration, which involves the simultaneous transfer of a phenyl group and a proton, is suggested. (P.C.H.)

**27519** ELECTRON SPIN RESONANCE OF IRRADIATED SINGLE CRYSTALS OF ALANINE: PROTON–DEUTERON EXCHANGE REACTION OF A FREE RADICAL IN THE SOLID STATE. Koichi Itoh (Tokyo Univ.) and Ichiro Miyagawa. J. Chem. Phys., 40: 3328-34(June 1, 1964).

The p-d exchange reaction of radicals in irradiated crystals of deuterium-substituted alanine $CH_3CHND_2COOD$ was studied by the ESR technique. It was shown that this exchange does not take place for the molecules in the crystal, but only for the radicals. The exchange rate is very slow at room temperature: exchange is hardly detectable within one month after irradiation. As the temperature rises, however, the rate increases greatly; all the four protons of the radical $CH_2\dot{C}HR$ are exchanged after about 10 h of heating at 150°C. The exchange rate for the earlier period of heating is independent of radiation dosage, while that for the later period depends on dosage. The activation energy and the frequency factor for the first step were found to be 24.6 ± 1.5 kcal/mole and $1 \times 10^{10} \sim 4 \times 10^{11}$/sec, respectively. (auth)

**27520** RELAXATION IN EUROPIUM CHELATES. M. L. Bhaumik (Electro-Optical Systems, Inc., Pasadena, Calif.). J. Chem. Phys., 41: 574-5(July 15, 1964).

The fluorescence rise curve of the 613-mμ line arising out of the transition $^5D_0 - {}^7F_2$ of the $Eu^{3+}$ ion in the piperidine adduct of a four-ligand europium dibenzoylmethide chelate is shown. The decay time of the level $^5D_1$ of europium was measured to be 1 μsec. The observed decay time is too short to be radioactive and, therefore, must be the result of competition between radiative and nonradiative processes where the latter is dominant. The results support the assumption that the energy is transferred to a higher level, and the relaxation time to reach the emitting level from the higher level is of the order of 1 μsec. This long relaxation time must be the result of the weak coupling of the ion levels with the surroundings. (C.E.S.)

**27521** RADIOLYSIS OF ACID AQUEOUS SOLUTIONS OF AQUOPENTAAMMINE- AND HEXAAMMINECOBALTIC IONS. D. Katakis and A. O. Allen (Brookhaven National Lab., Upton, N. Y.). J. Phys. Chem., 68: 1359-62(June 1964). (BNL-7579)

On irradiation with γ rays in acid solution, the aquopentaammine and hexaammine complexes of Co(III) decompose to give Co(II) and nitrogen. The decomposition is inhibited by bromide, chloride, and bisulfate ions, but seems to require the presence of Co(II) ions. The reaction is thought to involve an attack on the complexes by OH radicals, catalyzed by Co(II). (auth)

**27522** ABSOLUTE RATE CONSTANTS FOR H ATOM REACTIONS IN AQUEOUS SOLUTIONS. J. P. Sweet and J. K. Thomas (Argonne National Lab., Ill.). J. Phys. Chem., 68: 1363-8(June 1964).

The radiolysis of ferric sulfate solutions in $10^{-2}$ N sulfuric acid saturated with hydrogen gas has been carried out with short 1-μsec pulses on a linear electron accelerator and with larger 0.01-sec pulses on a Van de Graaff electron accelerator. Examination of the results gave the rate constant for H atom recombination $2k_1 = 2.0 \times 10^{10}\ M^{-1}\ sec^{-1}$ and the rate constant for the H atom reaction with ferric ion under these conditions as $k_2 = 9.0 \times 10^7\ M^{-1}\ sec^{-1}$. The rate constant for the reaction of H atoms with hydrogen peroxide was also measured spectroscopically by following at 365 mμ the $Cl_2^-$ transient formed via $H + H_2O_2 \xrightarrow{\text{rate determining}} OH + H_2O$, $OH + Cl^- \xrightarrow[\text{fast}]{H^+ + Cl^-} Cl_2^-$. This was found to be $0.90 \pm 0.1 \times 10^8\ M^{-1}\ sec^{-1}$. These results are discussed and related to other rate constants in solution and in the gas phase. (auth)

**27523** PHOTOLYSIS AND RADIOLYSIS OF PROPARGYL BROMIDE. M. Trachtman (Univ. of Pennsylvania, Philadelphia and Frankford Arsenal, Philadelphia). J. Phys. Chem., 68: 1415-19(June 1964).

The radiation and photochemistry of propargyl bromide in the liquid phase was studied in the presence and absence of free-radical scavengers at 25°. The gaseous products from radiolysis were hydrogen, acetylene, and methylacetylene, whereas only methylacetylene was observed in photolysis. The failure of oxygen and diphenylpicrylhydrazyl to inhibit acetylene formation was attributed to its formation via an ion-molecule reaction suggested by a study of the pressure dependence of the mass spectrum of propargyl bromide. The data do not permit any conclusions regarding the extent of formation of acetylene via hot radical and excited molecule reactions. (auth)

**27524** THE RADIATION-INDUCED CHAIN REACTION BETWEEN NITROUS OXIDE AND HYDROGEN IN AQUEOUS SOLUTIONS. C. H. Cheek and J. W. Swinnerton (Naval Research Lab., Washington, D. C.). J. Phys. Chem., 68: 1429-32(June 1964).

The radiation chemistry of solutions containing mixtures of nitrous oxide and hydrogen was studied. Nitrous oxide oxidizes hydrogen by a radiation-induced chain reaction which proceeds moderately in neutral solution and quite efficiently in strongly alkaline solution. Oxygen inhibits the chain reaction in neutral solution, but has no effect in strongly alkaline solution. The lack of dose-rate dependence is attributed to chain-terminating reactions with impurities which predominate over radical–radical combination. Mechanisms are proposed to account for the observations. The results account in part for an alternate interpretation of the sigmoid increase in $G(N_2)$ at high pH in irradiated nitrous oxide solutions. (auth)

**27525** THE SONOLYTIC DECOMPOSITION OF ORGANIC SOLUTES IN DILUTE AQUEOUS SOLUTIONS. I. HYDROGEN ABSTRACTION FROM SODIUM FORMATE. M. Anbar and I. Pecht (Weizmann Inst. of Science, Rehovoth, Israel). J. Phys. Chem., 68: 1460-5(June 1964).

Deuterated formate ions were sonolyzed in dilute aqueous solutions and the HD produced was determined. The yield of HD was found to be independent of solute concentration from 0.005 to 0.1 M. The yield of HD was diminished in both strongly acid and alkaline solutions. The results indicate the formation of hydrogen atoms under sonolytic conditions. The yield of "molecular" hydrogen formed under the same conditions is 50 times greater than that of hydrogen atoms. (auth)

**27526** THE SONOLYTIC DECOMPOSITION OF ORGANIC SOLUTES IN DILUTE AQUEOUS SOLUTIONS. II. THE SONOLYSIS OF ISOPROPYL ALCOHOL. M. Anbar and I. Pecht (Weizmann Inst. of Science, Rehovoth, Israel). J. Phys. Chem., 68: 1462-5(June 1964).

The sonolytic decomposition of isopropyl alcohol in aqueous solutions under argon was investigated following the evolution of hydrogen and the formation of acetone. It was found that the yield of hydrogen produced significantly exceeds the yields of molecular and atomic hydrogen. The sonolytic decomposition of isopropyl alcohol is not scavenged by nonvolatile hydrogen atoms scavengers. It was concluded that the sonolytic decomposition of isopropyl alcohol takes place in the cavities, where the high transient temperatures induce the monomolecular dehydrogenation of the alcohol. Hydrogen abstraction by a bimolecular process has been observed at high concentrations of isopropyl alcohol (>0.1 M). (auth)

**27527** RADIOLYSIS OF METHANE-$C^{14}$. William P. Hauser (Mellon Inst., Pittsburgh). J. Phys. Chem., 68: 1576-9(June 1964). (RRL-122)

A study was made of the initial yield of ethylene and the role of products in methane radiolysis. The radiolyses of

methane-$^{14}C$ with added ethylene and of methane with added ethylene-$^{14}C$ were carried out. The results show that both ethylene and propylene are important products; ethylene is a primary product (initial G = 1.1) and part of it is converted to ethane and propane during radiolysis, while propylene probably is not formed from ethylene. (D.L.C.)

**27528** PRODUCTION OF METHYL RADICALS IN THE RECOIL CHEMISTRY OF CARBON-11. Robert H. Schuler (Mellon Inst., Pittsburgh and Brookhaven National Lab., Upton, N. Y.). J. Phys. Chem., 68: 1618-20(June 1964). (RRL-130; BNL-7843)

A study on thermalization of recoil $^{11}C$ atoms as methyl radicals from the $^{12}C(n,2n)$ reaction in liquid hydrocarbons was conducted using iodine to scavenge the methyl radicals. Gas chromatography was used to detect the methyl iodide activity after interfering activity was removed by $Br_2$ treatment. The results for cyclohexane indicate that ~3% of the activity is methyl iodide, and the effects of oxygen were determined. Similarly, 2,2,4-trimethylpentane show a 3.2% activity in the methyl iodide fraction, while benzene gave only 0.16%. The addition of 10% benzene to 2,2,4-trimethylpentane reduces the methyl iodide fraction to 2.2%. The results are compared with the literature, and general aspects and reactions of recoil C atoms are discussed. (D.L.C.)

**27529** KINETICS OF THE γ-RADIATION-INDUCED POLYMERIZATION OF ETHYLENE IN ALKYL CHLORIDES. Richard H. Wiley (Univ. of Louisville, Ky.), N. T. Lipscomb, C. F. Parrish, and J. E. Guillet. J. Polymer Sci., Pt. A, 2: 2503-11(June 1964).

A study was made of the kinetics and mechanism of the liquid-phase, γ-induced, alkyl chloride solution polymerization of ethylene. The γ radiation was provided by a $4.07 \times 10^5$ r/hr. $^{60}Cr$ source. The kinetics of these polymerizations were studied up to 10% conversion and over the temperature range 0 to −25°C. Three solvents (n-propyl chloride, iso-propyl chloride, and tert-butyl chloride) were used with concentrations of ethylene ranging from 6.76 to 8.89 moles/l. Two different grades of ethylene were used: the first contained an upper limit of 1000 ppm of oxygen, the second 60 ppm. The ethylene containing only 60 ppm of oxygen was found to give a smaller induction period, and faster rate of polymerization than the ethylene containing 1000 ppm. Activation energies of 5.0 kcal./mole for the reaction in n-propyl chloride and 7.4 kcal./mole for the reaction in tert-butyl chloride were observed for the temperature range studied. These values were higher than the 4.4 kcal./mole obtained for the bulk polymerization of ethylene in this temperature range. The order of the reaction with respect to ethylene concentration in n-propyl chloride at 0°C was found to be 1.41. Although the heterogeneity of the system is a complicating factor, this rate expression agrees well with the general scheme proposed for other heterogeneous polymerizations. Molecular weight information, which showed an increase in molecular weight with increasing temperature, led to the conclusion that a termination step involving weakly reactive solvent radicals may be important. (auth)

**27530** RADIATION-INDUCED COPOLYMERIZATION OF ACRYLONITRILE WITH METHYL METHACRYLATE. Yoneho Tabata, Yoshio Hasizume, and Hiroshi Sobue (Tokyo Univ. and Dainippon Celloid Co., Tokyo). J. Polymer Sci., Pt. A, 2: 2647-56(June 1964).

Radiation-induced copolymerization of acrylonitrile with methyl methacrylate was investigated over a wide range of temperatures. The rate of copolymerization decreased linearly with the molar concentration of acrylonitrile in the liquid-state copolymerization at 15°C. However, the rate of copolymerization increased linearly with the concentration of acrylonitrile in the solid state at −78°C. The rate of copolymerization was proportional to the square root of the dose rate in an equimolar mixture of the monomers at 15°C. The apparent activation energy of the copolymerization was 4.62 kcal./mole in an equimolar mixture of the monomers. Monomer reactivity ratios were determined from the experiments at various temperatures. From these results, the differences of the activation energies in the propagation steps were obtained as follows: $E_{11}^{\ddagger} - E_{12}^{\ddagger} = 2.76$ kcal./mole; $E_{22}^{\ddagger} - E_{21}^{\ddagger} = 2.58$ kcal./mole. (auth)

**27531** RADIATION CROSSLINKING OF POLYETHYLENE-POLYFUNCTIONAL MONOMER MIXTURES. George Odian and Bruce S. Bernstein (Radiation Applications Inc., Long Island City, N. Y.). J. Polymer Sci., Pt. A, 2: 2835-48(June 1964).

Polyfunctional monomers such as allyl methacrylate, allyl acrylate, and diallyl maleate were found to greatly enhance the radiation cross linking of polyethylene. The radiation dose for incipient gelation was decreased by a factor of approximately 25 by the presence of small amounts of these monomers. The ultimate scission/cross linking ratio were unchanged by the presence of these monomers. The swelling behavior of the gels followed the Flory-Rehner equation. The monomer-cross linking process was compared to the monomer-free process as regards the physical properties (tensile strength, elongation, modulus) of the cross-linked materials. A mechanism is presented for the enhancement of polyethylene cross linking by polyfunctional monomers. (auth)

**27532** RADIATION-INDUCED POST POLYMERIZATION OF TRIOXANE IN THE SOLID STATE. K. Hayashi, H. Ochi, and S. Okamura (Japanese Assn. for Radiation Research on Polymers, Osaka). J. Polymer Sci., Pt. A, 2: 2929-46(June 1964).

Trioxane, the cyclic trimer of formaldehyde, is easily polymerized by ionizing radiation in the solid state at a temperature slightly below the melting point. It was found that this post-polymerization is analogous to in-source polymerization, but its overall activation energy is more than 40 kcal/mole, which is much larger than for in-source polymerization. A kinetic scheme is proposed for the post-polymerization, which accounts for the experimental results. In-source polymerization probably occurs by an ionic mechanism, but two different mechanisms co-exist in the post-polymerization. One is probably initiated by the decomposition of a product produced by the ionizing radiation in the presence of oxygen. The other has yet to be clarified, but it does not seem to be due to trapped radical or ionic species. The thermal decomposition of the polymer formed and the influence of additives, such as methanol, and benzene, on post-polymerization were also studied. (auth)

**27533** THE CHANGE IN PROPERTIES OF POLYETHYLENE BY IRRADIATION. Max Mozisek (Research Inst. for Tech. of Rubber and Plastics, Gottwaldov, Czechoslovakia). Jaderna Energie, 10: 120-5(Apr. 1964). (In Czech)

In a sample of polyethylene with a branched chain and medium molecular weight of 20,000 the first part of the insoluble fraction was formed after the absorption of a radiation dose of $1.7 \times 10^8$ rad. The net structure remained stable under a stress of 0.2 kp/cm$^2$ up to a temperature of 350 ± 5°C. The strength and modulus of the net structure, measured at 150°C, increased in proportion with the dose of irradiation. Mechanical properties of an irradiated sam-

ple could be improved by orientation at 110 to 150°C. An oriented irradiated polyethylene was found to have a perfect shape memory and its contraction could be limited by a secondary irradiation. The irradiated oriented polyethylene can be used in packaging, or for the insulation of conductors. (OTS)

**27534** RADIOLYSIS OF METHYL ISOBUTYL KETONE AND METHYL CYCLOHEXANONE AND OF THEIR SOLUTIONS CONTAINING URANYL NITRATE. Jiri Teply, Milada Teichmannova, Bohumil Bartonicek, Igor Janovsky, Jan Kriz, and Jaromir Moravec (Inst. for Nuclear Research, Czechoslovak Academy of Sciences, Rez.). Jaderna Energie, 10: 126-32(Apr. 1964). (In Czech)

Experimental data on radiolysis of methyl isobutyl ketone (MIK) and methyl cyclohexanone (MCH) and their solutions containing water and uranyl nitrate are presented. In the presence of air, consumption of molecular $O_2$ was determined: $G(O_2) = 14$ and 31 for MIK and MCH, respectively. In presence of air peroxidic substances were formed. Yield increased with increase of uranyl nitrate concentration; the yield of acid products was 0.4 and 0.1 for MIK and MCH. Peroxidic substances were not produced in deaerated ketones. Some reduction of hexa- to tetravalent U occurred in deaerated solutions. Reaction mechanisms and radiolytic processes are discussed. MIK was found to be more resistant to radiation than MCH. (auth)

**27535** RADIATION-INDUCED GRAFT POLYMERIZATION IN THE GASEOUS PHASE. A. V. Vlasov, N. V. Mikhaylov, L. G. Tokareva, S. R. Rafinov, B. L. Tseflin, and P. Ya. Glazunov. Khim. Volokna, No. 6, 24-8(1963).

The method of radioinduced graft copolymerization in the gas phase was applied to the modification of synthetic fibers. The purpose of the study was to obtain a desired polymer orientation by direct synthesis and, at the same time, to inhibit the formation of homopolymers. Experiments were conducted with oriented polyamide (capron) and polyolefin (polypropylene or polyethylene) fibers as backbone polymers. The fibers were irradiated in the presence of vapors of the following monomers: vinyl compounds (acrylonitrile, methyl methacrylate, styrene, acrylic acid, or vinyl acetate); olefins (ethylene, propylene, or butadiene); or acetylene monomers (acetylene, phenylacetylene, or propargyl alcohol). The reactions were conducted with purified dry materials. The equipment is described briefly. The results of the copolymerization were evaluated from the gain in weight of the fiber. The amount of homopolymer formed was determined by extraction with suitable solvents. It was shown that: this method of copolymerization makes it possible to obtain graft copolymers based on any of the three monomer types considered; the weight of the polymer grafted onto the fiber can attain up to 100% that of the original fiber; and the copolymers contain little or no homopolymer. The radiation yield of the grafted copolymer increases with a decrease in the dose rate and with an increase in the monomer vapor pressure. The reaction can be conducted in a mixture of nitrogen and monomer vapors without a marked decrease in yield. Infrared absorption spectra indicate that additives grafted onto oriented fibers are themselves oriented. Thermomechanical data confirm the building up on oriented fibers of a new part, an additive with its own oriented structure, which may change the physicomechanical properties of the entire fiber system. It was concluded that radioinduced graft copolymerization in the gas phase may be used to prepare combined fibers with a double structure that combines properties of the initial fiber with those of the second fiber constituent, e.g., the strength of the original fiber with the electrical properties of a conjugated polymer. (A.I.D. Press, Vol. 2: No. 170, Feb. 1964)

**27536** THERMOLUMINESCENCE AND ELECTRON PARAMAGNETIC RESONANCE SPECTRA OF ORGANIC COMPOUNDS IRRADIATED BY FAST ELECTRONS. M. V. Alfimov, V. G. Nikol'skii, and N. Yu. Buben (Inst. of Chemical Physics, Academy of Sciences, USSR). Kinetika i Kataliz, 5: 268-76(Mar.-Apr. 1964). (In Russian)

The thermoluminescence of organic compounds (polyethylene, polystyrene, rubber, paraffin, cyclohexane, and others) irradiated by fast electrons at 77°K was studied. Irradiated amorphous organic specimens exhibited characteristic luminescence dependence on the dose, with the maximum at doses of 1 to 5 Mrad. The optical "whitening" of specimens during low-temperature radiolysis reduced considerably (10 to 100 fold) thermoluminescence intensity and in some cases affected the electron paramagnetic resonance spectra. It was concluded that radioluminescence of organic compounds is the result of the recombination of ions stabilized in the compounds during low-temperature radiolysis. (tr-auth)

**27537** THE RADIOCHEMICAL FORMATION OF KETENE-IMINE GROUPS IN THE LOW-TEMPERATURE POLYMERIZATION OF ACRYLONITRILES. Christel Schneider and Jakob Herz (Universität, Cologne). Makromol. Chem., 73: 128-40(1964). (In German)

Polyacrylonitrile, formed by bulk polymerization at low temperatures under the influence of ionizing radiation, showed an absorption band at 2030 $cm^{-1}$, which originated in ketene-imine groups of the polymer. There are two different theories on the formation of these groups: formation during the course of the polymerization, especially by the termination reaction, and formation by the effect of the radiation on the polymer chains. To clarify the problem, acrylonitrile was bulk-polymerized at –78 and –196°C. In addition, the polymerization was done in different solvents at –78°C. The dependence of the relative concentration of ketene-imine groupings on the dose rate and the total dose was studied. Polyacrylonitrile was also irradiated in vacuum and in the presence of air. The concentration of ketene-imine groups in the polymers was found to be dependent upon the square root of the dose rate, but independent upon the total dose. These results led to the conclusion that the bulk polymerization of acrylonitrile at low temperatures proceeds predominantly according to a radical mechanism, and that the ketene-imine groups are formed in the termination step. (auth)

**27538** STUDIES ON THE POLYMERIZATION OF BIFUNCTIONAL MONOMERS. V. POLYMERIZATION OF o-BISEPOXYETHYLBENZENE AND 1,2-5,6-BISEPOXYHEXANE. Chuji Aso and Yuzo Aito (Kyushu Univ., Fukuoka, Japan). Makromol. Chem., 73: 141-4(1964).

o-Bisepoxyethylbenzene and 1,2-5,6-bisepoxyhexane were polymerized by using several catalysts. Some properties of the polymers suggest that cyclopolymerization takes place in the polymerization of these bisepoxides. o-Bisepoxyethylbenzene was also polymerized by gamma irradiation. Higher rates of polymerization were observed just below the melting point of the monomer. (auth)

**27539** REACTIONS OF ELECTRONS IN THE γ-RADIOLYSIS OF LIQUID ALKANES. G. Scholes and M. Simic (Univ. of Newcastle-upon-Tyne, Eng.). Nature, 202: 895-6(May 30, 1964).

The radiation chemistry of liquid alkanes, e.g., cyclohexane, was studied using various amounts of $N_2O$ as solute,

which is an efficient scavenger for electrons. The amount of nitrogen formed from $N_2O$ was used to determine the numbers of scavengable electrons from γ-irradiated cyclohexane. (R.E.U.)

**27540** RADIOLYSIS OF SOLID CYCLOHEXANE–BENZENE MIXTURES AT — 196°C. P. J. Dyne and J. Denhartog (Chalk River Nuclear Labs., Ont.). Nature, 202: 1105(June 13, 1964).

Hydrogen yields in the radiolysis of solid cyclohexane–benzene mixtures are reported. Results for samples prepared by plunging liquid samples into liquid nitrogen were different from those prepared by condensation of pre-mixed vapor. The yields obtained from condensed-vapor samples were similar to those for liquids. Results for a solid cyclohexane–biphenyl mixture are also presented. (M.C.G.)

**27541** THERMOLUMINESCENCE OF IRRADIATED NYLON. Yohta Nakai, Koji Matsuda, Saburo Ohara, and Ki-ichi Kimura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 13-22(1962). (In Japanese)

Experiments on the thermoluminescence of Nylon, as a typical polyamide, were carried out using uv light, γ rays, and electron beams, and the results were compared with those of polyethylene previously reported. The luminescence intensity increased with increasing degree of crystallinity or decreasing degree of polymerization. The intensity of the luminescence curve was saturated at about 1 Mrad. When kept under various conditions after irradiation, the luminescence intensity of the peak at −160°C decreased remarkably compared with that of the peak at −130°C. Since Nylon generally becomes very brittle with uv irradiation, the thermoluminescence of Nylon preirradiated by uv light was also studied, and the more complicated phenomena were found in comparison with the polymer of simple structure such as polyethylene. (auth)

**27542** RADIATION-INDUCED THERMOLUMINESCENCE OF POLYSTYRENE SENSITIZED BY p-TERPHENYL. Yohta Nakai, Koji Matsuda, Mitsuo Ikenaga, and Ki-ichi Kimura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 23-9(1962). (In Japanese)

Solid solutions of p-terphenyl in polystyrene as a plastic scintillator were irradiated with ionizing radiation and uv light at −196°C, and then the thermoluminescence emitted upon subsequent heating was measured. In a comparatively low dose range the intensity of thermoluminescence increased with increasing concentration of p-terphenyl dissolved in polystyrene, and the peak of intensity-vs-temperature curve occurred at about −176°C for pure polystyrene, about −162°C for pure p-terphenyl, and about −166°C for polystyrene solution containing a small amount of p-terphenyl. It was found that in the last case the polystyrene emission is much suppressed and that the thermoluminescence from the solution is mainly due to the solute p-terphenyl molecules. This finding supports the hypothesis that the radiation energy absorbed in polystyrene is transferred to p-terphenyl molecules and leads to the excitation of them followed by luminescence. The spectral results obtained are also consistent with the energy transfer model. ESR spectra on the irradiated specimens did not reveal any obvious correlation to thermoluminescence. (auth)

**27543** THERMOLUMINESCENCE OF LIQUID SCINTILLATOR BOMBARDED WITH HIGH ENERGY ELECTRON BEAM. Yohta Nakai, Koji Matsuda, Mitsuo Ikenaga, Naoko Shiomi, Torao Takagaki, and Ki-ichi Kimura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 29-36(1962). (In Japanese)

Strong thermoluminescence of xylene bombarded with high-energy electrons was observed when a small quantity of sensitizer, for example p-terphenyl, was added. Xylene alone exhibited about only one-tenth of the light intensity observed in the presence of the sensitizer. The increase in the intensity by addition of the sensitizer appears to be explained by a transport of excitation energy from the solvent to the sensitizer. The mechanism of energy transport in the liquid is also discussed. (auth)

**27544** RADIATION-INDUCED GRAFT COPOLYMERIZATION TO CELLULOSE. XIV. GRAFTING OF TERNARY MIXTURES ONTO CELLULOSE. Ichiro Sakurada, Toshio Okada, Fujiko Kimura, and Shigeyuki Hatakeyama. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 37-44 (1962). (In Japanese)

The radioinduced graft copolymerization of ternary mixture of comonomers, butadiene–styrene–acrylonitrile, onto cellulose was studied. The mutual grafting by γ rays proceeds very smoothly at a comonomer concentration of 80% (methanol is used as a solvent) and a comonomer composition of butadiene : styrene : acrylonitrile = 1 : 4 : 5. A very high percent graft such as 20,000% can be obtained in favorable cases without losing fiber structure. Although the mutual grafting of comonomers is complicated, it seems that the tremendous gel effect and radicals produced by radiolysis of the grafted polymers lead to such a very high degree of grafting. In the case of the preirradiation technique by electron beams, the grafting occurred much less easily than in the case of the mutual grafting. (auth)

**27545** RADIATION-INDUCED GRAFT COPOLYMERIZATION TO CELLULOSE. XV. COMPARISON OF COPOLYMERIZATION AND GRAFT COPOLYMERIZATION ONTO CELLULOSE OF STYRENE-ACRYLONITRILE. Ichiro Sakurada, Toshio Okada, Fujiko Kimura, and Ayako Torikai. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 44-8(1962).

The copolymerization of styrene–acrylonitrile was compared with graft copolymerization of the monomers onto cellulose by γ irradiation. The rate of copolymerization exhibits a maximum at compositions of about 90% acrylonitrile, whereas the percent graft shows a distinct maximum at an acrylonitrile composition of 60%. This difference is discussed in terms of the swelling property of the graft copolymer in the solution of comonomer mixtures. (auth)

**27546** RADIATION-INDUCED GRAFT COPOLYMERIZATION TO CELLULOSE. XVI. GRAFTING OF BUTADIENE-STYRENE ONTO CELLULOSE AND REGRAFTING OF THE GRAFTED CELLULOSE. Ichiro Sakurada, Toshio Okada, Fujiko Kimura, and Ayako Torikai. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 48-59(1962). (In Japanese)

The grafting of butadiene–styrene onto cellulose at a certain composition of comonomers proceeded autocatalytically to a remarkably high percent graft by a direct irradiation method. After butadiene–styrene had been grafted, cellulose was further grafted with styrene or butadiene–styrene. The regrafted polymer was about 70,000 times as heavy as the original cellulose. The preirradiation regrafting onto grafted cellulose was also studied using electron beams. The degree of grafting was much lower than that obtained by the direct irradiation method. For comparison with the regrafting onto grafted cellulose, experiments were carried out in the presence of the butadiene–styrene popcorn polymer. It was found that the grafting onto popcorn polymer proceeded more rapidly than the regrafting onto the grafted cellulose. From the

results of the grafting onto both a graft copolymer and a popcorn polymer by the direct irradiation method, it may be concluded that the residual double bond of butadiene in copolymers can play an important role as an initiation site of polymerization. Although the grafting of the binary mixture at an optimum condition is kinetically similar to a popcorn polymerization, the grafting mechanism is complicated. A combined effect of swelling of the gel, formation of radicals in the gels, homocopolymerization, and some other unknown factors might lead to a very high degree of grafting. (auth)

**27547** RADIATION-INDUCED GRAFT COPOLYMERIZATION TO POLY (VINYL ALCOHOL). XVII. GRAFTING WITH BINARY MIXTURES OF STYRENE-ACRYLONITRILE ONTO POLY (VINYL ALCOHOL) FIBER. Ichiro Sakurada, Toshio Okada, and Shigeyuki Hatakeyama. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 61-70(1962). (In Japanese)

Grafting with binary mixtures of styrene–acrylonitrile onto poly (vinyl alcohol) fiber was carried out using a methanol–water mixture as a solvent. The experiments were carried out mainly by a direct irradiation technique using $\gamma$ rays. The per cent graft of styrene–acrylonitrile goes through a maximum as the composition of comonomer changes, the position of the maximum varying with the concentration of comonomer changes, the position of the maximum varying with the concentration of comonomer. The highest per cent grafts can be obtained in the range of 10 to 20% of styrene, 20 to 30% of acrylonitrile, and 50 to 70% of solvent (methanol : water = 9 : 1). The grafting reaction initially proceeded with a very low rate, and after a certain degree of grafting had been reached, the rate of grafting increased as the reaction proceeded. Finally the rate decreased, and the per cent graft reached a limiting value. The preirradiation graftings were also carried out. The per cent graft was generally very small, but a maximum, though not so distinct, was obtained at a certain composition of comonomer. The composition of the graft polymer was determined by infrared analysis. It was found that the grafted copolymer was richer in acrylonitrile than nongrafted copolymer. The graftings with binary mixtures of styrene–methyl methacrylate, styrene–acrylic acid, styrene–methacrylic acid, and methyl methacrylate–vinyl acetate were also studied. In these cases a maximum per cent graft was observed at a certain composition of the comonomer mixture. On the other hand, in the case of grafting with binary mixtures of styrene–vinyl acetate, and methyl methacrylate–acrylonitrile, the per cent graft vs comonomer-composition curve, did not show any maximum. (auth)

**27548** RADIATION-INDUCED GRAFT COPOLYMERIZATION TO POLY (VINYL ALCOHOL). XVIII. GRAFTING WITH TERNARY MIXTURES OF STYRENE-BUTADIENE-ACRYLONITRILE. Ichiro Sakurada, Toshio Okada, and Shigeyuki Hatakeyama. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 71-9(1962). (In Japanese)

Grafting of ternary mixture of comonomers, styrene–butadiene–acrylonitrile, onto poly (vinyl alcohol) fiber and powder was studied and compared with the previous results. The experiments were carried out mainly by a direct irradiation technique using $\gamma$ rays. The grafting of ternary mixture of comonomers proceeded more smoothly, and products of extremely high percent grafts (10,000 to 20,000%) could be obtained at some favorable compositions of comonomers. For comparison with the grafting by the direct irradiation technique, a preirradiation technique was also applied. In this case, the degree of grafting was generally very low. Some properties of the graft copolymers were also measured. (auth)

**27549** RADIATION-INDUCED GRAFT COPOLYMERIZATION TO POLY (VINYL ALCOHOL). XIX. GRAFTING OF STYRENE ONTO POLY (VINYL ALCOHOL) FIBER SPUN FROM A NEUTRAL COAGULATING BATH. Ichiro Sakurada, Toshio Okada, and Yasushi Asano. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 79-83 (1962). (In Japanese)

Grafting of styrene onto poly (vinyl alcohol) fiber spun from a neutral coagulating bath was studied. A direct irradiation grafting was carried out in vacuum at 45, 55, and 65°C, using methanol as a solvent. The induction period in the grafting reaction was observed in all cases and became shorter with increasing grafting temperature. The rate of grafting at 55°C was the highest. The structure of graft fiber was also studied with x-ray diffractometry. Both wide and small angle scatterings were measured. The crystallinity of graft fiber could be raised by heat treatment. The peak of small angle scattering with fiber grafted with a small amount of styrene shifted toward lower angle by heat treatment. Some mechanical properties of graft fibers were measured. (auth)

**27550** RADIATION-INDUCED GRAFT COPOLYMERIZATION TO POLY (VINYL ALCOHOL). XX. GRAFTING OF STYRENE ONTO POLY (VINYL ALCOHOL) FIBER SPUN FROM AN ALKALI COAGULATING BATH. Ichiro Sakurada, Toshio Okada, and Yasushi Asano. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 84-8(1962). (In Japanese)

Grafting of styrene onto poly (vinyl alcohol) fiber spun from an alkali coagulating bath (fiber II) was carried out. The induction period in grafting onto fiber II was much shorter than that of grafting onto poly (vinyl alcohol) fiber spun from a neutral bath (fiber I), but the rate of grafting onto fiber II was smaller than that of fiber I. Both wide and small angle scattering were measured with an x-ray diffractometer. X-ray measurement showed that both the intensity and the position of the peak of the small-angle scattering changed less in the case of Fiber II than in the case of graft fiber I. Tenacity of graft fiber II increased by heat treatment. (auth)

**27551** STRUCTURE OF POLYBUTADIENE GRAFTED ONTO CELLULOSE OR POLY (VINYL ALCOHOL). Ichiro Sakurada, Toshio Okada, and Ayako Torikai. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 89-94(1962). (In Japanese)

The structures of polybutadiene and of polybutadiene grafted onto cellulose or poly (vinyl alcohol) were determined by infrared analysis. It was found that polybutadiene polymerized by $\gamma$ irradiation did not contain the cis-1,4 structure, and the ratio of the trans-1,4 structure to the vinyl (1,2) structure was about 4. In the case of polybutadiene grafted onto cellulose by a mutual irradiation, the cis-1,4 structure could not be found either. The value of the trans-1,4/vinyl (1,2) lay between 2 and 1.5 for this experiment. The amount of vinyl structure increased with the increasing per cent graft. It was also found that the value of trans-1,4/vinyl (1,2) was about 2 in the case of polybutadiene grafted onto poly (vinyl alcohol). (auth)

**27552** PREIRRADIATION GRAFTING ONTO POLYPROPYLENE FIBER WITH BINARY MIXTURES OF STYRENE-SULFUR DIOXIDE AND SOME PROPERTIES OF GRAFT FIBER. Ichiro Sakurada, Toshio Okada, Tetsuya Shioda, and Yoshiharu Matsumoto. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 95-101 (1962).

Polypropylene fiber was grafted with binary mixtures of styrene–sulfur dioxide. Experiments were carried out by a preirradiation technique using electron beams from a Van de Graaff accelerator. A maximum per cent graft was observed at a concentration of 10 to 20% of sulfur dioxide in the comonomer solution. It was found that the mole ratio of styrene to sulfur dioxide in the grafted polysulfone chain was approximately two and was practically independent of the concentration of sulfur dioxide in the comonomer solution. The grafting of styrene–sulfur dioxide onto polypropylene fiber increased dyeability of the fiber. Dyed graft fiber showed comparatively high fastness to washing and color fastness to light. The melting temperature was raised from 180°C for the original fiber to 228°C for the 150% grafted. The shrinkage of the graft fiber by heating was very small. The graft fiber was resistant to alkali. Some mechanical properties were also measured. (auth)

**27553** EFFECT OF MONOMER CRYSTALLINE STATE ON RADIATION INDUCED SOLID STATE POLYMERIZATION. Masanobu Nishii, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 103-8(1962). (In Japanese)

The melting phenomenon of trioxane crystals below the melting point was found using the NMR method, and its influence on the rate of solid state polymerization was studied. By keeping trioxane crystals at 50 to 55°C, just below the melting point, for a long time, a narrow width of NMR absorption was observed, whose intensity decreased with standing time. On the other hand, the rate of polymerization was decreased by this treatment. The reason for the melting phenomenon is not due to localization of impurities or production of any reaction products owing to this treatment, but a conversion of molecular configuration between boat and chair in form is proposed. (auth)

**27554** RADIATION-INDUCED SOLID STATE POLYMERIZATION OF TETRAOXANE. Koichiro Hayashi, Masanobu Nishii, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 109-10(1962).

The radioinduced polymerization of tetroxane was compared with that of trioxane. Under gamma irradiation at a dose rate of $2.5 \times 10^4$ r/hr the crystal became gradually opaque. After 18 hr irradiation a polymer crystal with the shape of the monomer crystal was obtained at 94% conversion. However, no polymer was obtained in the melt or in solution. The conversion was linear during irradiation and was completed after 20 hr irradiation at 80°C. It was found that tetroxane had a wider temperature range than trioxane (25 to 64°C) and the former polymerized more easily at the same temperature interval below the melting point. The G-values for monomer disappearance in the two monomers at the maximum rate of polymerization were G(tetroxane), $7 \times 10^4$ (100°C) and G(trioxane), $6 \times 10^3$ (55°C). A cationic mechanism was supported by mass spectrometry. (P.C.H.)

**27555** RADIATION INDUCED SOLID STATE POLYMERIZATION OF 2,6-DIOXASPIRO-(3,3)-HEPTANE. Haruhiko Watanabe, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 111-117(1962). (In Japanese)

2,6-dioxaspiro-(3,3)-heptane was synthesized and the study of its solid state polymerization under the action of ionizing radiation was carried out. The rate of polymerization was much smaller than for trioxane and 3,3-bis(chloromethyl)oxetane. The activation energy was evaluated at 9.2 kcal/mole. The post-polymerization was also found and the rate was accelerated in the presence of air. The polymer formed was insoluble, infusible, and amorphous. This monomer has two equivalent oxetane groups in the molecule. The amount of unreacted oxetane group remaining in the polymer was much more than in one obtained in liquid by an ionic catalyst, but the amount diminished as polymerization progressed. (auth)

**27556** THE MECHANISM OF RADIATION INDUCED SOLID STATE POLYMERIZATION OF 3,3 BIS (CHLOROMETHYL)-OXETANE. Haruhiko Watanabe, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 119-26(1962). (In Japanese)

Radioinduced solid state polymerization of 3,3 bis(chloromethyl)oxetane (BCMO) has an induction period that is longer in the lower dose rate, at lower polymerization temperature, and in the shock-cooled crystal. However, the irradiated crystal in an induction period is post-polymerized at room temperature. From observations of dilatometry, viscometry, and infrared absorption spectra of the irradiated monomer crystal, there is no oligomer formed in the period of induction. On the other hand, the intrinsic viscosity number of the polymer formed increases with reaction time in the early stage of polymerization. It was considered that the active species induced by radiation was accumulated in the crystal during the induction period and that propagation takes place at a limited concentration. At a latter stage of polymerization, the intrinsic viscosity number of the polymer is decreased because of the monomer crystal owing to the existence of the polymer formed and any products or to radiation damage. These arguments were confirmed by the observation of molecular weight distribution of the polymer formed. (auth)

**27557** RADIATION INDUCED SOLID STATE COPOLYMERIZATION OF OXETANES. Haruhiko Watanabe, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 127-38(1962). (In Japanese)

It is well known that 3,3-bis(chloromethyl)oxetane (BCMO), 3,3-bis(bromomethyl)oxetane (BBMO), 3-ethyl-3-chloromethyloxetane (ECMO), and 3-ethyl-3-bromomethyloxetane (EBMO) are polymerized very easily in the solid state under gamma irradiation. Radioinduced solid state copolymerization was carried out in the systems of BCMO–BBMO, BCMO–ECMO, ECMO–EBMO, and EBMO–BBMO. Using melting point measurement, differential thermal analysis, and x-ray diffraction analysis methods, it was confirmed that monomer mixtures formed a solid solution and the copolymer obtained had a random configuration. From the copolymer composition curves, molecular reactivity ratios were estimated to be always $r_1 = r_2 = 1$. This is quite different from the case of the $BF_3 \cdot O(C_2H_5)_2$-catalyzed solution copolymerization in which $r_1 = r_2 = 1$. (auth)

**27558** THE SATURATION OF POLYMER YIELD IN THE RADIATION-INDUCED SOLID STATE POLYMERIZATION OF β-PROPIOLACTONE. Koichi Takakura, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 139-45(1962). (In Japanese)

The radioinduced solid state polymerization of β-propiolactone was carried out in order to study the saturation phenomenon of polymer yield. For the rapidly cooled monomer crystal, the polymer yield tended to reach the limiting value of about 16% at the dose above $3 \times 10^5$r. However, if the mixture of polymer and monomer was melted, refrozen, and then irradiated, once again a certain amount of polymer was formed. To investigate the effects

of the irradiation products of monomer, such as the polymer and the other products, the monomer was subjected to preirradiation in the liquid state and at −196°C was polymerized in the solid state at −78°C. It was found that the polymerization was retarded to an appreciable extent and the saturated polymer yield was decreased as compared with pure monomer. The saturated polymer yield decreased with increase in polymerization temperature over the temperature range studied. On the basis of the results obtained, the saturation of polymer yield may be satisfactorily interpreted in terms of the crystal imperfections initially present and the disruption of the crystal lattice caused by radiation damage and by formation of the polymer and other products during irradiation. (auth)

**27559** PHOTO-POLYMERIZATION OF β-PROPIOLACTONE SENSITIZED BY URANYL NITRATE. Masahiro Sakamoto, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 147-54(1962). (In Japanese)

The photopolymerization of β-propiolactone and some other ring compounds in the presence of sensitizer such as uranyl nitrate in organic solvents was investigated. It was found that the photopolymerization of β-propiolactone, ε-caprolactone, β-dimethyl-β-propiolactone, and diketene could be performed using uranyl nitrate as sensitizer. From the analysis of absorption spectra the formation of complexes between monomer and sensitizer was found to be necessary for this polymerization. Moreover, oxygen was effective but DPPH and benzoquinone inhibited the polymerization. From the results of the kinetic study, the following equation was adopted for the rate of polymerization. $Rp = kp\,(\varphi K/kt)^{1/2}\, I^{1/2}\, [M]^{3}\, [C]^{1/2}$. (auth)

**27560** RADIATION-THERMOLUMINESCENCE STUDY ON RADIATION-INDUCED SOLID STATE POLYMERIZATION OF DIKETENE. Kazumasa Kamada, Koichiro Hayashi, and Seizo Okmura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 155-62(1962). (In Japanese)

The relation between radiation-thermoluminescence and radioinduced post-polymerization of diketene was studied in attempting to obtain more direct evidence for the mechanism of radioinduced polymerization. One (−175°C) of four luminescence peaks of diketene corresponds well to post-polymerization under the conditions such as dose and storage and is considered as active species of initiation of post-polymerization. From the results of radiation-thermoluminescence of polymeric and monomeric mixtures of diketene, it is obvious that at −196°C active species are frozen within the monomer crystal without initiating post-polymerization, and post-polymerization takes place at the temperature corresponding to a luminescence peak of −175°C observed in radiation-thermoluminescence. (auth)

**27561** RADIATION-THERMOLUMINESCENCE-SPECTRA OF β-PROPIOLACTONE. Kazumasa Kamada, Sumihiko Mori, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 163-6(1962). (In Japanese)

Six peaks were found in the luminescence curve in the radiation-thermoluminescence of β-propiolactone. Using several cut-off filters, spectra of the peaks were observed and their wave lengths were estimated to be 4450 Å for the lowest peak (−175°C) and 5600 Å for the three higher peaks (−80, −60, and −47°C). (auth)

**27562** ELECTRICAL-CONDUCTIVITY OF PRE-IRRADIATED MONOMER CRYSTAL. Masahiro Sakamoto, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 167-76(1962). (In Japanese)

The radioinduced solid state polymerization of trioxane at 30°C and of β-propiolactone at −78°C in an electric field (5000 v) was observed. However, the electric field had no influence on polymer conversion. It is well known that the polymerizations proceed by an ionic mechanism. It is obvious, therefore, that charged species responsible for the initiation in solid state polymerization cannot be separated in the electric field. On the other hand, increases in electric conductivities of monomer crystals by preirradiation were recognized at −78°C. The thermal changes of the conductivities were observed and it was concluded that trapped electron contributed to such electric conductivities. (auth)

**27563** MASS SPECTROMETRIC STUDIES ON THE PRIMARY PROCESSES IN THE RADIATION-INDUCED POLYMERIZATION OF CYCLIC COMPOUNDS. Koichi Takakura, Syuji Fujioka, Norikatsu Otsuka, Motoyoshi Hatada, Koichiro Hayashi, Kozo Hirota, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 177-82(1962).

Spectrometric studies were made on the primary processes in the radioinduced polymerization of cyclic ethers, lactones, diketene, and ketene in an attempt to find a clue for understanding the initiation mechanism of the process. In general, the radioinduced polymerization of cyclic ethers occurs only in the solid state and the reaction is considered to be probably cationic. This suggests that the lifetime of the initiating species is comparatively long and the initiating species may be positive ions. No conclusion could be drawn as to whether the ions observed in the mass spectra may act as initiators of ion propagation chains. (P.C.H.)

**27564** RADIATION INDUCED SOLID STATE POLYMERIZATION OF SORBIC ACID. Kikuo Fujiwara, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 183-98(1962). (In Japanese)

The radioinduced polymerization of trans-(2)-trans-(4)-sorbic acid was carried out mainly in the solid phase. Polymerization kinetics were elucidated, and the structure of the polymer obtained was studied. The polymerization reaction proceeds by a radical mechanism. The polymer formed is amorphous and has no crosslinking structure. The intrinsic viscosity $[\eta]$ is $0.4 \sim 1.0$ in D.M.F. solution. Infrared spectra showed that the polymer has almost a 1,4-trans structure. In addition, radioinduced polymerization of Na and K salts of sorbic acid, sorbamide, and methyl sorbate were also examined. (auth)

**27565** RADIATION-INDUCED POLYMERIZATION OF 2-VINYL-PYRIDINIUM SALTS. Syuji Fujioka, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 199-207(1962). (In Japanese)

In the radioinduced polymerization of 2-vinylpyridinium salts in aqueous solutions, the dependence of the polymerization rate on the monomer concentration is extremely high. This is interpreted by the mutual electrostatic repulsion between monomer and polymer. The polymerization rate in the solid state is controlled by the monomer crystal lattice structure. Polymers obtained were amorphous and have the property of polymer electrolyte in aqueous solution. The radical mechanism was adopted for these polymerizations both in the liquid and in the solid states. (auth)

**27566** RADIATION-INDUCED COPOLYMERIZATION OF FORMALDEHYDE WITH CARBONYL HALIDE. Tadao Natori, Koichiro Hayashi, and Seizo Okamura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 209-13(1962). (In Japanese)

The copolymerization of formaldehyde with phosgene by

irradiation with γ rays was undertaken. The molar ratio of phosgene in the copolymer obtained is between 0.001 and 0.005, and the physical properties of the copolymer, especially its thermal stability, are not so improved compared with formaldehyde homopolymer. As a carbonyl halide, formyl fluoride was polymerized by anionic catalysts. However, the polymer was unstable at room temperature and decomposed. The irradiation of γ rays on formyl fluoride was done at temperatures between −196 and 20°C, but no polymer was obtained. (auth)

**27567** SYNTHESIS OF TERT-AMYL ALCOHOL BY IRRADIATION OF ELECTRON BEAMS FROM THE VAN DE GRAAFF ACCELERATOR. II. LIFE-TIME MEASUREMENT OF THE PROPAGATING RADICALS BY USE OF THE ROTATING SECTOR METHOD. Kozo Hirota and Motoyoshi Hatada. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 215-18(1962).

2-Propanol and ethylene were irradiated by intermittent electron beams that were turned on and off by the rotating sector openings, equipped between the irradiation window of a Van de Graaff accelerator and the irradiation cell. The ratio of the off-to-on-time was kept constant at 5 throughout the experiment. G-values for tert-amyl alcohol and acetone produced, which were the main products detectable by gas chromatography, were found to be inversely proportional to the square root of the dose rate. Without inhibitors the amount of the product increased linearly with irradiation time. By the addition of iodine or DPPH, some retardation in tert-amyl alcohol production was observed. However, the formation of acetone was increased by the addition of iodine. (P.C.H.)

**27568** SYNTHESIS OF TERT-AMYL ALCOHOL BY IRRADIATION OF ELECTRON BEAMS FROM THE VAN DE GRAAFF ACCELERATOR. III. DEPENDENCY OF ETHYLENE PRESSURE ON THE G VALUE OF t-AMYL-ALCOHOL AND OTHER BY-PRODUCTS. Kozo Hirota, Motoyoshi Hatada, and Norikatsu Ohtsuka. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 219-21(1962).

The mechanism and effects of ethylene pressure on the yields of products in the radiolysis of the ethylene−2-propanol system were investigated. Gas chromatographic analysis was used to identify the products, which were methyl isopropyl ether, diisopropyl ether, acetaldehyde, propylene oxide, acetone, tert-butyl alcohol, tert-amyl alcohol, tert-hexyl alcohol, and tert-heptyl alcohol. Methyl isopropyl ether, acetaldehyde, propylene oxide and tert-butyl alcohol showed a little dependency on ethylene pressure. Therefore, the ethylene is considered not to play an important role in their formation. However, tert-heptyl alcohol did not depend on ethylene pressure and ethylene is indispensable for its formation. G values of methyl isopropyl ether, diisopropyl ether, and tert-butyl alcohol increased slightly with increasing ethylene pressure. The G-value of acetone showed a tendency to increase as a marked dependency of ethylene pressure. (P.C.H.)

**27569** RADIATION-INDUCED ADDITION OF ACETALDEHYDE TO CYCLO- AND NORMAL HEXENES. II. A SUPPLEMENTAL REPORT FOR THE FIRST REPORT. Kozo Hirota, Jun'ichi Takezaki, and Motoyoshi Hatada. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 223-5(1962).

Studies were made on the yields of gases from the irradiated mixtures and effects of benzene and cyclohexane added to the mixtures of cyclohexene and acetaldehyde. Hydrogen, methane, and carbon monoxide were the main gaseous products. They were produced in almost equal amounts, although the latter two components decreased with increasing cyclohexene fraction in the initial mixture. Considering the magnitude of $G(H_2)$, $G(CO)$, and $G(CH_4)$, radioinduced decompositions of aldehyde and cyclohexene may be said to proceed in parallel with the telomerization. The addition of benzene to the mixture reduced the G-value for methylcyclohexyl ketone. Cyclohexane is regarded as an energy donor in the cyclohexane−benzene mixture. (P.C.H.)

**27570** RADIATION-INDUCED REACTION OF ACETALDEHYDE−CYCLOHEXENE MIXTURE. [PART] III. Kozo Hirota, Akira Shingyouchi, and Motoyoshi Hatada. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 227-33(1962). (In Japanese)

In order to compare the effect of irradiation source, the use of electron beams and/or uv light instead of gamma rays was used as the initiating agent of the telomerization of an acetaldehyde−cyclohexene mixture. Besides methyl cyclohexyl ketone hitherto found, acetoin was identified in both products and also 1-acetyl-2-cyclohexenyl cyclohexene (ACC) in the products irradiated by electron beams. Several unknown products were also found. It was concluded that the formation of acetoin occurs via the bimolecular excitation process in acetaldehyde, and ACC via the recombination of acetylcyclohexane radical and cyclohexenyl radical. (P.C.H.)

**27571** IRRADIATION OF THE MIXTURES OF OLEFINE AND ALKYLHALIDES AND OR ALKYLAMINES. Kozo Hirota, Jun'ichi Takezaki, and Motoyoshi Hatada. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 235-7(1962).

Radiolysis studies were made on systems of alkyl halides and ethylene and/or propylene. Irradiation was carried out with a γ source at the dose rate of $8 \times 10^4$ to $4 \times 10^5$ r/hr. The G-values of the telomers obtained are tabulated. (P.C.H.)

**27572** GRAFT-COPOLYMERIZATION BY USE OF SECONDARY ALPHA-RAY. IV. RADIATION-INDUCED GRAFT-COPOLYMERIZATION TO POLYPROPYLENE WITH SECONDARY ALPHA-RAY PRODUCED BY THE $^{10}B(n,\alpha)^7Li$ REACTION. Kozo Hirota and Masao Umezawa. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 239-40(1962).

Studies were made on the effects of pre-irradiation with α particles on γ-radioinduced graft polymerization of styrene to polypropylene. The results showed that the grafting per cent on the polypropylene film increased in accordance with increase of the grafting time. However, the grafting per cent of the second layer was always larger than that of the third layer, indicating the effects of α rays. The grafting per cent of polypropylene fibers increased also in accordance with increase of grafting time. The effects of α rays were more marked in the fibers than in the case of the films. This may be due to the increased area of the irradiated polymer. (P.C.H.)

**27573** RADIATION-INDUCED CO-GRAFT-POLYMERIZATION. 1. CO-GRAFT-POLYMERIZATION OF MONOMER MIXTURES ON POLYPROPYLENE FIBRES. Masao Umezawa and Kozo Hirota. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 241-51(1962). (In Japanese)

Graft polymerization of monomer mixtures was investigated on polypropylene fibers that had been pre-irradiated in air by electron beams from a 2-Mev Van de Graaff accelerator. It was found that in the monomer mixtures of styrene−maleic anhydride the grafting percentage increased markedly. (auth)

**27574** RADIATION-INDUCED CO-GRAFT-POLYMERIZATION. 2. CO-GRAFT-POLYMERIZATION OF THE MONOMER MIXTURES OF STYRENE–MALEIC ANHYDRIDE ON POLYPROPYLENE FIBRES AND PROPERTIES OF GRAFTED SAMPLES. Masao Umezawa and Kozo Hirota. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 251-8(1962). (In Japanese)

Electron irradiation on polypropylene fibers was performed using a 2-Mev Van de Graaff accelerator. Low dose rate and small total irradiation dose, besides addition of some diluent to the grafting system, were required to obtain the small grafting percentage. In the case of fibers co-grafted with styrene–maleic anhydride, the dyeing with disperse dyes and/or basic dyes was much enhanced, and heat resistibility was also improved. (auth)

**27575** RADIATION-INDUCED CO-GRAFT-POLYMERIZATION. 3. CO-GRAFT-POLYMERIZATION OF THE MONOMER MIXTURES ON POLYETHYLENE FIBRES AND PROPERTIES OF GRAFTED SAMPLES. Masao Umezawa and Kozo Hirota. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 258-64(1962). (In Japanese)

Electron irradiation of polyethylene fibers was performed using a 2-Mev Van de Graaff accelerator. In the case of fibers co-grafted with styrene–maleic anhydride, vinyl acetate–maleic anhydride, and vinyl acetate–itaconic anhydride, dyeing with disperse dyes and/or basic dyes was very enhanced and also heat resistibility was improved. (auth)

**27576** RADIATION-INDUCED CO-GRAFT-POLYMERIZATION. 4. CO-GRAFT-POLYMERIZATION OF MULTICOMPONENT MONOMER SYSTEMS ON SEVERAL POLYMERS. Masao Umezawa and Kozo Hirota. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 264-71(1962). (In Japanese)

Graft-polymerization of multicomponent monomer systems was investigated on polypropylene fibers that had been pre-irradiated in air by electron beams from a 2 Mev Van de Graaff accelerator. Grafting percentage was higher in two-component systems than in three-component systems. In the co-grafting of two-component systems on polypropylene fibers, simultaneous irradiation gave results similar to those of the pre-irradiation. Grafting percentage was higher in raw fibers than in commercial fibers of Cashimilon (wet spinning). However, stretched fibers and unstretched fibers of Nylon-6 (melt spinning) showed no difference in the grafting percentage. (auth)

**27577** DECAY BEHAVIOR OF FREE RADICALS IN IRRADIATED CRYSTALLINE POLYETHYLENE. Isamu Nitta, Shunichi Ohnishi, and Shun-ichi Sugimoto. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 273-4(1962).

Studies were made to determine whether the morphological difference of polyethylene could affect the free radical decay in the sample. The samples were sealed in a vacuum and irradiated at –196°C with electron beams from a Van de Graaff accelerator at a dose of 10 Mrad. Decay of the free radicals produced in the irradiated samples at 25°C was investigated by means of ESR spectroscopy. The decay was found to be a function of the heat treatment temperature. (P.C.H.)

**27578** ANISOTROPY OF ESR SPECTRUM OF IRRADIATED POLY ($\beta$-PROPIOLACTONE). Isamu Nitta, Shun-ichi Ohnishi, Shun-ichi Sugimoto, and Koichiro Hayashi. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 275-6(1962).

Anisotropy of the ESR spectrum of the irradiated polymer was measured and analyzed to identify the free radical produced in the polymer and also to obtain molecular orientation in the sample. As the rotation angle varied, the spectrum changed from a four-line one to a six-line one. The feature of the spectral change indicates that the spectrum is a double-triplet one, in which the doublet splitting changes with the angle, and, therefore, suggests that the radical responsible for the spectrum may be $-CH_2-CH-CO-O-$ or $-CH_2-CH-O-CO-$. The hyperfine coupling tensor of the $\alpha$ proton, the principal values of the tensor, and also the directions of the principal axes were calculated, and the results are discussed. (P.C.H.)

**27579** PHOTO-INDUCED CHANGE OF ORGANIC FREE RADICALS AS STUDIED BY ESR. I. CONVERSION OF THE ALLYL-TYPE TO THE ALKYL-TYPE RADICALS IN IRRADIATED POLYETHYLENE. Isamu Nitta, Shun-ichi Ohnishi, and Shun-ichi Sugimoto. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 277-8(1962).

Photochemical changes in the allyl-type radical $-CH_2-CH-CH=CH-CH_2-$ in irradiated polyethylene were studied by means of ESR spectroscopy. Upon uv irradiation, the seven-line spectrum, due to the allyl-type radical, gradually changes to a six-line spectrum, which is quite similar to the one previously assigned to the alkyl-type radical $-CH_2-CH-CH_2-$. During the change the total concentration of the radicals remained constant. The initial slope of the curves was found proportional to the light intensity, while the saturation concentration was independent of the intensity. Rough estimates of the rate constants as well as the quantum yield were calculated from the experimental results. (P.C.H.)

**27580** PHOTO-INDUCED CHANGE OF ORGANIC FREE RADICALS AS STUDIED BY ESR. II. CONVERSION OF THE ALLYL-TYPE TO THE ALKYL-TYPE RADICALS IN IRRADIATED n-HEXADECENE-1. Isamu Nitta and Shun-ichi Ohnishi. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 279-80(1962).

The photoinduced conversion of the allyl-type radical was studied in 1-hexadecene. Upon uv illumination (high-pressure mercury lamp) the spectrum gradually changed to an eight-line one, which could be attributed to the alkyl-type radical by assuming $A\alpha = A\beta_1 = 22.3$ and $A\beta_2 = 44.6$ gauss. By analogy with the case of polyethylene, similar photoinduced conversion of the allyl-type to the alkyl-type radicals seemed to occur: $CH_2=CH-CH-CH_2-CH_2- \rightleftharpoons CH_2=CH-CH_2-CH-CH_2-$. (P.C.H.)

**27581** PHOTO-INDUCED CHANGE OF ORGANIC FREE RADICALS AS STUDIED BY ESR. III. CONVERSION OF THE ALLYL-TYPE TO THE ALKYL-TYPE RADICALS IN IRRADIATED CYCLOHEXENE. Isamu Nitta and Shun-ichi Ohnishi. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 280-1(1962).

The photoinduced conversion of the allyl-type to the alkyl-type radicals was studied in cyclohexene by ESR spectra. Upon uv illumination at –196°C the spectrum gradually changed to an eight-line one. The total concentration of the radicals was constant during the change and the production curve of the eight-line spectrum was found to reach a saturation, as in the case of polyethylene. The saturation concentration was also quite similar (53%). The eight-line spectrum could be assigned to an alkyl-type radical by assuming $A\alpha = A\beta_1 = 23.2$ and $A\beta_2 = 43.9$ gauss. When the uv illuminated sample was kept in the dark at –196°C, the eight-line spectrum gradually returned to some extent, with the intensity of the peak becoming decreasing. (P.C.H.)

**27582** ESR STUDY OF FORMATION PROCESS OF "ORGANO-SULFUR RADICAL" IN IRRADIATED SINGLE CRYSTAL OF L-CYSTINE DIHYDROCHLORIDE. Isamu

Nitta, Kazuyuki Akasaka, and Shun-ichi Ohnishi. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 283-7(1962).

Studies were made on the formation process of the organo-sulfur radical RS· in $^{60}Co$ γ-irradiated single crystals of L-cystine dihydrochloride. The results indicate that in L-cystine dihydrochloride, the primary ionization, probably occurring uniformly in the molecule, readily comes onto sulfur-sulfur bond at liquid nitrogen temperature and that with rising temperature the formation of the organo-sulfur radical RS· follows simply by the breakage of the bond of the damaged disulfide group. The results also seem to infer the general occurrence in disulfides, of the localization of unpaired spin on sulfur upon irradiation at liquid-nitrogen temperature. (P.C.H.)

**27583** FLUORESCENCE OF Nd($4f^3$) BY IRRADIATION INTO THE CHROMIUM ABSORPTION BANDS OF THE SYSTEM $Al_2O_3$: Cr, Nd. W. Heitmann, A. Moeller, and G. V. Schultz (Forschungsinstitut, Darmstadt, Ger.). Phys. Letters, 10: 26-7(May 15, 1964).

Samples of $Al_2O_3$: 1% Cr, 1% Nd were excited by radiation from a high pressure mercury lamp. The samples showed the absorption spectrum of Nd ($4f^3$). The fluorescence spectra in the range 8700 to 9500 Å are illustrated. (C.E.S.)

**27584** THERMOLUMINESCENCE INDUCED BY PLASTIC DEFORMATION IN ALKALI HALIDES. E. Panizza (Università, Milan). Phys. Letters, 10: 37-8(May 15, 1964).

Samples of KBr crystals were x irradiated at room temperature, cooled to liquid nitrogen temperature, subsequently plastically deformed, and raised to room temperature at a constant rate. Thermoluminescence induced by deformation was observed between the temperature of deformation and room temperature. It is supposed that color centers and x-ray charged traps are ionized by interaction with dislocations moving through the sample during plastic deformation. This interaction is studied by taking into account the radiationless capture of carriers freed from the x-ray charged traps by plastic deformation. (C.E.S.)

**27585** THERMOLUMINESCENCE IN ALUMINIUM-CONTAINING QUARTZ. M. Schlesinger (Univ. of Pittsburgh). Phys. Letters, 10: 49-50(May 15, 1964).

The thermoluminescence in x-irradiated aluminum-containing quartz, both germanium-doped and germanium-free, is investigated. The general glow curves and their spectral composition were considered. A germanium-doped crystal exhibits two main glow peaks at 460 and 660°K. The germanium-free sample exhibits a main glow peak at 570°K. All these peaks were found to have the same spectral composition, which consists of a broad band peaking at about 485 mμ. (C.E.S.)

**27586** COLOR CENTERS IN X-IRRADIATED HALOPHOSPHATE CRYSTALS. R. K. Swank (General Electric Research Lab., Schenectady, N. Y.). Phys. Rev., 135: A266-75(July 6, 1964).

Measurements were made of the properties of the anisotropic color centers produced by x rays in single crystals of calcium fluoro- and chlorophosphate. The measurements include optical absorption, fluorescence, and photoconductivity. Transformations of the centers under thermal and optical excitation were studied. Three distinct color centers are necessary to account for all the observed color bands, and it is suggested that these are composed of appropriate combinations of halogen vacancies. Coloration results when such defects capture electrons during x irradiation. Subsequent color changes are thermally induced by diffusion of these defects and their aggregation to form new complexes. (auth)

**27587** OPTICAL AND THERMAL BLEACHING STUDY OF IRRADIATED SODIUM CHLORIDE. P. V. Sastry and K. A. McCarthy (Tufts Univ., Medford, Mass.). Phys. Rev. Letters, 12: 690-2(June 22, 1964).

A systematic study was made of irradiated synthetic sodium chloride crystals in order to understand the origin, behavior, and relation to the other observed absorption bands of an absorption maximum at 670 mμ. Color and spectral changes produced by bleaching at room temperature with F-band light, by heating and quenching, and by plastic deformation followed by white light bleaching are described. (M.J.T.)

**27588** RADIATION POLYMERIZATION OF ETHYLENE IN LARGE SIZE LABORATORY REACTORS. A. D. Abkin, A. L. Auer, A. Kh. Breger, et al. Plasticheskie Massy, No. 2, 3-6(1964).

Experiments were conducted on the radiation polymerization of ethylene in large model reactors, with a 1–2 liter capacity. It was found that the temperature field in the reaction volume of the apparatus can be calculated with satisfactory accuracy on the basis of the assumptions that: heat transfer during the polymerization process is effected by means of heat conduction; heat evolution in the reaction zone is due mainly to the exothermic character of the polymerization of ethylene; the polymerization rate and, consequently, heat evolution in the reaction volume of the apparatus, are constant; and the temperature field gradient along the axis of the apparatus is assumed equal to zero. The rate and radiochemical yield of the radiation polymerization of ethylene were found to be independent of the specific surface of the reaction volume of the apparatus. It was concluded that reactors for radiation polymerization of ethylene on an industrial scale can be designed by considering the dependence of the rate and radiochemical yield of the process on the pressure, temperature, dose rate absorbed, and other parameters of the process. It is noted that reactors for gas phase radiation polymerization of ethylene should have a branched heat-exchange surface. (OTS)

**27589** GAMMA IRRADIATION POLYMERIZATION OF ISOBUTENE AND β-PROPIOLACTONE AT LOW TEMPERATURE. C. David, F. Provoost, and G. Verduyn (Centre d'Etude de l'Energie Nucleaire, Mol, Belg.). Polymer, 4: 391-9(Sept. 1963).

It was shown that ionic oxides only slightly modify the rate and molecular weight for the solid-state polymerization of β-propiolactone and isobutene, whereas the effect was much larger in the liquid phase. Resistance measurements of the pure monomers during solid-state polymerization were made. The possibility of an ionic mechanism of polymerization according to the model proposed by Fowler is discussed to explain conductivity induced in polymers by ionizing radiation. (auth)

**27590** FREE RADICAL REACTIONS IN IRRADIATED POLYETHYLENE. M. G. Ormerod (Royal Military Coll. of Science, Shrivenham, Wilts, Eng.). Polymer, 4: 451-7(Dec. 1963).

Different samples of the same polyethylene were irradiated at 77°K. They were, then warmed to room temperature and the decay of the free radicals in the samples was followed using electron spin resonance. By using samples that had different ratios of sample weight to container volume it was found that the rate of radical decay was linearly

dependent on the pressure of the radioinduced hydrogen gas above the sample. Since the number of cross-links formed was unaffected it was concluded that the hydrogen gas increased radical mobility. (auth)

**27591** THE RADIATION CHEMISTRY OF SOME POLYSILOXANES: AN ELECTRON SPIN RESONANCE STUDY. M. G. Ormerod and A. Charlesby (Royal Military Coll. of Science, Shrivenham, Swindon, Wilts, Eng.). Polymer, 4: 459-70(Dec. 1963).

Electron spin resonance spectroscopy was used to study the formation and behavior of free radicals produced in some polysiloxanes by ionizing radiation. A comparison was made of the polysiloxanes with vinyl and hydrogen group substituents. At 77°K, unstable methyl radicals were observed and their subsequent reactions were studied. It was found that there are too few radicals produced at 77°K to account for the formation of crosslinks. A mechanism not involving a free radical intermediate was found to be responsible for most of the radioinduced crosslinking. Room temperature irradiation of a liquid polysiloxane, which contained vinyl side groups, produced stable free radicals. These free radicals could not be produced by low temperature irradiation and subsequent warming. This evidence indicates that the radiochemical process in polysiloxanes differs between the glass and liquid states. (auth)

**27592** THE RADIATION CHEMISTRY OF POLYMETHACRYLIC ACID, POLYACRYLIC ACID AND THEIR ESTERS: AND ELECTRON SPIN RESONANCE STUDY. M. G. Ormerod and A. Charlesby (Royal Military Coll. of Science, Shrivenham, Swindon, Wilts, Eng.). Polymer, 5: 67-88(Feb. 1964).

The radioinduced reactions in polymethacrylic and polyacrylic acids and their methyl, ethyl, and n-butyl esters were studied using electron spin resonance (e.s.r.). The polymers were irradiated at 77°K and their e.s.r. spectra recorded at that temperature. Subsequently they were warmed to room temperature and the free radical decays and reactions followed. Work with certain additives led to the conclusion that trapped electrons rather than free radicals are responsible for the unpaired spins initially observed at 77°K. The e.s.r. results were correlated with the radiation chemistry of the polymers and compared with those observed in other polymers, in which the ionic species are believed to be less stable. (auth)

**27593** THE HOT IODINE SUBSTITUTION REACTION IN GASEOUS METHYL IODINE. R. J. Cross, Jr. and R. L. Wolfgang (Yale Univ., New Haven). Radiochim. Acta, 2: 112-116(1964). (NYO-1957-35)

Chemical reactions of hot atomic I formed by recoil from a photoneutron emission process, $(\gamma,n)$ were studied. The yield of the hot substitution, $^{126}I + CH_3I \rightarrow CH_3{}^{126}I + I$ was determined. The probability of this process, compared to analogous reactions of hot H atoms, was found to be low. A possible reason for what appears to be a generally low efficiency of gas phase hot halogen atom substitution reactions is discussed. (auth)

**27594** ELASTOMERS FOR USE IN RADIATION FIELDS. PART VII. EFFECT OF FILLERS IN A STYRENE-BUTADIENE ELASTOMER. EFFECT OF GAMMA RADIATION ON SUPPLEMENTAL ELASTOMERS. POST IRRADIATION EFFECTS ON THREE ELASTOMERS. Robert Harrington (General Electric Co., Richland, Wash.). Rubber Age (N. Y.), 88: 475-83(1960).

The effects of specific variables on the radiation resistance of elastomeric polymers were investigated. Data and discussion are presented on the effects of various filler loading materials on the radioinduced changes in the physical properties of a styrene–butadiene elastomer and post-irradiation effects on three elastomers as reflected by physical property changes at various times after removal from the radiation source. The results showed that all of the styrene–butadiene elastomers become increasingly hard, stiff, and brittle on prolonged exposure to $\gamma$ irradiation. In all instances the hardness of the materials increased with increasing radiation exposure while the elongation was reduced. It was found that the type and amount of filler incorporated into a styrene–butadiene elastomer can greatly regulate the changes induced by $\gamma$ irradiation, especially at low and intermediate doses. It was concluded that elastomers are unaffected by post-irradiation effects until at least a year after removal from the radiation source as reflected by physical property changes. Results of radiation effects on butadiene, chlorosulfonated polyethylene, fluorocarbons, silicones, and urethane are also discussed. (P.C.H.)

**27595** INSERTION MECHANISMS OF ATOMIC CARBON: DEGRADATION OF ALLENE PRODUCED BY REACTION WITH ETHYLENE. Maryan Marshall (Yale Univ., New Haven), Richard Wolfgang, and Colin MacKay. Tetrahedron Letters, No. 29, 2033-6(1963). (NYO-1957-34)

Recoil $^{11}C$ (half life 20.4 min) produced by the $^{12}C(\gamma,n)^{11}C$ reaction was reacted with ethylene and the allene separated and degraded by a fast technique. It was concluded that the hypothesis that both C–H and C=C insertion reactions are important in ethylene is supported. (P.C.H.)

**27596** RADIATION TRANSPORT IN THE ATMOSPHERE. P. I. Richards, W. D. Lanning, M. D. Torrey, and J. C. Rogers (Technical Operations Research, Aberdeen Proving Ground, Md.). Trans. Am. Nucl. Soc., 7: 5(June 1964).

**27597** PREVENTION OF THE RADIATION-INDUCED ENHANCEMENT OF THE OXIDATION RATE OF GRAPHITE. Robert M. Singer and Donald G. Schweitzer (Brookhaven National Lab., Upton, N. Y.). Trans. Am. Nucl. Soc., 7: 122(June 1964). (BNL-7838)

**27598** ARSENAZO I REAGENT FOR PHOTOMETRIC DETERMINATION OF SCANDIUM. V. A. Nazarenko and E. A. Biryuk (Inst. of General and Inorganic Chemistry, Academy of Sciences, Ukrainian SSR). Ukr. Khim. Zh., 29: 198-204(1963). (In Russian)

The effects of pH on the absorption spectra of complexes of arsenazo, arsenazo in strong sulfuric acid, and complexes of arsenazo with scandium in sulfuric acid were investigated. The maximum absorption spectra for complexes of arsenazo with scandium were found at pH 7.9 and 500 mμ. A maximum coloring developed with 3 to 3.5 mole/l ratio of arsenazo solution to scandium. The molar extinction coefficients is $1.73 \times 10^4$. Scandium and arsenazo form a 1·1 complex. The mechanism of the scandium–arsenazo reaction in the quinhydrazo compound is described. Scandium replaces the hydrogen in the arsonium compound. Scandium is linked by a coordinate bond. Conditions were found for the determination of 0.001% Sc and over, by means of arsenazo. (R.V.J.)

**27599** DESORPTION PROCESSES IN IONIZATION MANOMETERS IN THE CASE OF BOMBARDMENT OF OIL-COVERED SURFACES WITH SLOW ELECTRONS. S. Garbe (Philips Zentrallaboratorium GmbH, Aachen). Vakuum Tech., 12: 201-5(Nov. 1963). (In German)

During electron bombardment of oil-contaminated sur-

faces the desorption of cracking products was observed. For an oil with very low vapor pressure ($6 \times 10^{-8}$ torr for a silicone oil at 20°C) the number of adsorbed molecules was by many orders of magnitude greater than the number of molecules in the free space. Therefore, interaction and cracking of the oil molecules induced by the electrons occurred mainly with adsorbed molecules. Desorption rates were measured as function of the bombarding electron current and the electron energy. (auth)

**27600** EFFECT OF IONIZING RADIATION ON THE STRUCTURE OF POLYPROPYLENE. N. A. Slovokhotova, Z. F. Ilicheva, L. A. Vasilev, and V. A. Kargin (Karpov Inst. of Physics and Chemistry, Moscow). Vysokomolekul. Soedin., 6: 608-13(1964). (In Russian)

Infrared spectra were obtained for amorphous and isotactic polypropylene (PP) specimens irradiated in a vacuum with fast electrons and $^{60}Co$ γ rays at −196 and 25°C. The irradiated specimens showed absorption bands at 890 and 910 $cm^{-1}$ corresponding to the double bonds $\begin{matrix} R \\ R \end{matrix}\!\!>\!C = CH_2$ and $RCH = CH_2$. Their appearance is due to degradation of PP as a result of the irradiation. The bands at 1665 and 845 to 855 $cm^{-1}$ appearing in the spectra correspond to $\begin{matrix} R \\ R \end{matrix}\!\!>\!C = CHR$ bonds in the irradiated PP. A change in the band intensities at 1665 $cm^{-1}$ on heating the PP specimens irradiated at low temperature, and also the increase in intensity of absorption in the 1645 $cm^{-1}$ region point out to the formation of allyl radicals. The mechanism of the breakdown and crosslinking of PP during its irradiation was discussed. The effect of the phase state of PP and the irradiation temperature on the course of these processes was pointed out. (auth)

**27601** EPR STUDY OF THE KINETICS OF FREE RADICAL CONVERSIONS IN γ-IRRADIATED POLYPROPYLENE. V. K. Milinchuk and S. Ya. Pshezhetskii (Karpov Inst. of Physics and Chemistry, Moscow). Vysokomolekul. Soedin., 6: 666-71(1964). (In Russian)

A kinetic analysis of the hyperfine structure of EPR spectra in crystalline polypropylene confirmed the possibility of conversion of alkyl radicals into allyl and polyene radicals by the mechanism of free valence migration in the macromolecule. The activation energy of conversion of such radicals is from 4 to 6 ± 1 kcal/mole. (auth)

**27602** ANALYSIS OF LIQUID-PHASE PRODUCTS OF RADIOLYSIS AND RADIATION-CHEMICAL OXIDATION OF METHANOL. B. Ya. Ladygin. Zh. Analit. Khim., 19: 508-13(1964). (In Russian)

It was shown that all the main products of the initial stages of methanol radiolysis can be quantitatively determined by means of known and developed chemical and chromatographic methods. (auth)

**27603** PARAMAGNETIC SPECTRUM INVESTIGATIONS OF THE EFFECTS OF $\gamma^-$, $\beta^-$, AND PHOTO IRRADIATION ON ACETALDEHYDE AND FORMALDEHYDE. V. I. Smirnova, G. S. Zhuravleva, K. G. Yanova, and D. N. Shigorin. Zh. Fiz. Khim., 38: 742-5(Mar. 1964). (In Russian)

Electron paramagnetic spectra of $\beta^-$, $\gamma^-$, and photo irradiated acetaldehyde with $3 \times 10^6$- to $4 \times 10^6$-rad doses formed broken C—C and C—H, and possibly C—O bonds, in the polymer chain forming the radicals $CH_3-\dot{C}(=O)$, $CHO$ or $\sim O-\dot{C}(CH_3)-O\sim$. Beta and γ-irradiated formaldehyde at $7 \times 10^6$- to $7 \times 10^7$-rad doses breaks the polymer chain forming the radicals $\sim O-\dot{C}H-O\sim$ and $\sim CH_2-O-\dot{C}H_2$. (R.V.J.)

**27604** NEW DATA ON SENSITIZING FORMATION OF CATION-RADICAL FORMATION AT LOW-TEMPERATURE RADIOLYSIS OF FILMS CONTAINING AROMATIC AMINES. R. I. Milyutinskaya and Kh. S. Bagdasar'yan (Karpov Inst. of Physics and Tech., Moscow). Zh. Fiz. Khim., 38: 776-80(Mar. 1964). (In Russian)

Specimens prepared from polymer and amine solutions in methylene chloride in argon environment exposed to radiation at room temperature and at 77°K acquire colors: p-phenylenediamine became yellow with maximum absorption at 460 mμ, and N,N-dimethyl-p-phenylenediamine pink with maxima at 520 and 555 mμ. The radiochemical yield of N,N-dimethyl-p-phenylenediamine cation radicals is ~3. The radiochemical behavior of the two amine mixtures confirmed the sensitizing mechanism of cation-radical formation in the systems examined. Protection of electron contributing admixtures against radiation effects on polymethyl methacrylate is related to the pre-radical stages in radiolysis. (R.V.J.)

**27605** DECOMPOSITION OF AMMONIA BY γ RADIATION. Yu. A. Sorokin and S. Ya. Pshezhetskii (Moscow State Univ.). Zh. Fiz. Khim., 38: 798-801(Mar. 1964). (In Russian)

Radiation effects on ammonia in the gaseous phase at 1 to 6 atm pressure and at 15 to 180°C were studied. The magnitudes of $G(H_2)$ and $G(N_2)$ were determined. The effective activation energy of the process was 1 to 2 kcal/mole. The results were correlated with the data for the liquid phase. Small quantities of propene inhibited the production of nitrogen and hydrogen in the radiolysis of $NH_3$ and promoted the production of hydrazine. Probable schemes for the processes based on free radical reaction are suggested. (R.V.J.)

**27606** EFFECTS OF IONIZING RADIATION ON SOLID GLYCOGEN. E. A. Kuzicheva and M. A. Khenokh. Zh. Obshch. Khim., 34: 1329-34(Apr. 1964). (In Russian)

The effects of ionizing radiation on glycogen were studied in order to determine the changes in polysaccharides under the conditions excluding the effects of water radiolysis products, when all the effects are the result of primary ionization and molecular excitation of the irradiated material. Gamma irradiation of glycogen in the solid state resulted in macromolecular splitting along the α−1.4 and α−1.6 bonds. Radiochemical transformations of glycogen are followed by oxidation processes forming carbonyl compounds, $H_2CO$, organic acids, and dihydroxyacetone, with absence of glucose in split glycogen products. (R.V.J.)

**27607** THE CATALYTIC DEUTERATION OF SOME ACETYLENES AND DIOLEFINS ON PALLADIUM ALUMINA. Edwin Francis Meyer, II. Thesis. Evanston, Ill., Northwestern Univ., 1963. 152p.

The reactions of 1-butyne, 2-butyne, 1,2-butadiene, and 1,3-butadiene in the vapor phase and 3-hexyne in the liquid phase with deuterium were studied. The study of the reaction of 2-butyne was most thorough. The product of the reaction of 2-butyne with $D_2$ before the half-stage is simply 2,3-dideutero-cis-2-butene, as proved by mass spectrometry and nuclear magnetic resonance spectrometry. No exchange occurs in the unreacted 2-butyne. When 50-50 mixtures of $H_2$ and $D_2$ were used as the reductant, the results allow the following conclusions: no desorption of hydrogen occurs during the reaction before the half-stage; the H and D atoms are well mixed on the catalyst surface; and the isotope effect for the reaction is 1.6 in favor of

hydrogen. This means that the relative rate of adsorption of $H_2$ and $D_2$ during the reaction is 1.6. Once the half-stage is passed (i.e., all acetylene has reacted), the cis-2-butene isomerizes to trans-2-butene and small amounts of 1-butene, and hydrogenates to form n-butane. The deuterium contents and distributions in the products support the presently accepted mechanisms for isomerization and exchange. Studies of the non-steady state show that about 10 monolayers of 2-butyne react before selectivity is observed on a used catalyst; $10^2$ monolayers on a fresh catalyst. 1-Butyne yields 1-butene very selectively, with all deuterium in positions 1 and 2. Exchange occurs in the unreacted 1-butyne due to the acetylenic hydrogen, resulting in the smearing of the deuterium distribution in the product. The primary products of the reaction of 1,2-butadiene are cis-2-butene and 1-butene, with a small amount of trans-2-butene and a trace of butane. It isomerizes to light 2-butyne (ca 4% of products) in the presence of $D_2$. NMR shows the reaction to be straightforward, with no isomerization to other $C_4H_6$ isomers preceding hydrogenation. 1,3-Butadiene yields primarily 1-butene and trans-2-butene, with a small amount of cis-2-butene and a trace of butane. Strong evidence exists for four point adsorption of the diene to produce all products. An isotope effect causes the slight inhibition of 1-butene production in $D_2$. The results with 3-hexyne were analogous to those with 2-butyne in the vapor phase. Virtually the only product before the half-stage is 3,4-dideutero-cis-3-hexene, and no exchange occurs in the unreacted 3-hexyne. All evidence indicates that the same mechanistic path is followed in both the liquid and vapor phase hydrogenations of di-substituted acetylenes. (Dissertation Abstr., 24: No. 11, 1964)

**27608** IRRADIATION OF AQUEOUS SOLUTIONS OF BENZENE TO PRODUCE PHENOL. E. H. Engquist and J. J. Martin (Univ. of Michigan, Ann Arbor). 24p. (CONF-110-7)

From American Institute of Chemical Engineers 56th Annual Meeting, Houston, Dec. 1963.

Studies were made on the direct oxidation of benzene to phenol in an agitated aqueous medium under the catalysis of gamma radiation. The reaction proceeds at 10 atmospheres oxygen pressure and 190°C with a G-value of approximately 50 and at 10 atmospheres and 220°C with a G-value exceeding 200. The maximum concentration of phenol produced was 1.3 to 2.6 gm/liter of solution with an optimum temperature of 190°C. At 190 and 220°C the kinetics of phenol formation is significantly higher than the previously reported results. Continuous agitation of the solution during irradiation to insure better gas phase distribution in the liquid phase, and better distribution of benzene in the aqueous phase, may account for the significantly higher G-values obtained. Increasing the oxygen pressure to 50 atmospheres did not significantly alter the rate of formation of phenol over that obtained at 10 atmospheres. The kinetic data can be fitted to a first order exponential equation with a high degree of correlation significance. (P.C.H.)

**27609** THE UV PHOTOCHEMISTRY OF THYMIDYLYL-(3′ → 5′)-THYMIDINE (TpT). H. E. Johns, Mark L. Pearson, J. C. LeBlanc, and C. W. Helleiner (Univ. of Toronto). 32p. (CONF-534-1)

From Biophysical Society, 8th Annual Meeting, Chicago, Feb. 1964.

Irradiation of TpT by monochromatic light in the wavelength region 225 to 289 mμ results in the production of two chromatographically separable isomer dimers and two unknown photoproducts. The concentrations of the two dimers approach an equilibrium with TpT so that at 225 mμ only 2.5% of the monomer is in dimer form while at 289 mμ this value reaches 95%. The relative yields of these dimers are 5 : 1 independent of wavelength. One of the unknown photoproducts, which has an absorption maximum at 325 mμ, is produced irreversibly from TpT in low yields compared to the dimers. It in turn can be converted to a second unknown by radiation at 313 mμ. The second compound is converted back to the first at 240 mμ. Cross sections and quantum yields for all these photochemical reactions were measured as a function of wavelength. (auth)

**27610** THE FLUORESCENT DECAY OF CsI(Tl) EXCITED BY CHARGED PARTICLES. E. A. Womack, A. J. Lazarus, and M. Joseph (Massachusetts Inst. of Tech., Cambridge). 8p. (CONF-182-19)

From the 9th Scintillation and Semiconductor Counter Symposium, Washington, D. C., Feb. 1964.

The fluorescence from a CsI(0.08% Tl) scintillator excited by charged particles which come to a stop within the scintillator was measured for alpha particles, deuterons, and protons. In the region 0.1 to 0.6 microsecond after its initial rise, the fluorescent decay can be accurately described by a simple exponential. The characteristic time for this exponential decay was measured at several energies up to 28.7 Mev for $\alpha$ particles and 7.2 Mev for protons. A linear relationship was found between this decay time and the logarithm of the particle energy, $\tau = k \ln E + \tau_0$, where k and $\tau_0$ are constants which are characteristic of the type of stopping particle. (auth)

**27611** IRRADIATION OF POLYMERIZABLE ORGANIC MATERIALS BY FISSION PRODUCTS OF BORON-10. Donald E. Kline (to HRB-Singer, Inc.). U. S. Patent 3,137,633. June 16, 1964. Filed May 13, 1960.

A method is given for the selective irradiation of one area of an organic material without the use of masking devices. The method comprises providing the selected area with a coating or amount of boron-10 and subjecting the material to neutron bombardment to produce heavy charged particles. An example of the method is given in which a polystyrene antenna insulation is treated to improve its resistance to crazing. (D.L.C.)

## Separation Processes and Procedures

**27612** (BM-RI-6457) SOLVENT EXTRACTION RECOVERY OF THORIUM AND YTTRIUM FROM SILICEOUS COLORADO ORES. S. R. Borrowman and D. W. Bridges (Bureau of Mines. Salt Lake City Metallurgy Research Center). Oct. 1963. 18p.

Thorium and yttrium oxides were recovered from siliceous ores of the Powderhorn, Colo., area. Processing comprised (1) acid curing and subsequent (2) acid baking, (3) leaching, and (4) solvent extraction of thorium, using a primary alkylamine, and yttrium, using di-2-ethylhexyl phosphoric acid. About 95% of the contained thorium and yttrium was recovered from ore containing 1.2% $ThO_2$ and 0.5% $Y_2O_3$. The thoria product was 99% $ThO_2$; the yttria product was 77% $Y_2O_3$. A 150-to-1 concentration ratio was effected on the latter, but some contaminating lanthanon-group oxides remained. (auth)

**27613** (BM-RI-6469) EXPANDED INVESTIGATION OF BERYLLIUM SOLVENT EXTRACTION OF SPOR MOUNTAIN, UTAH, ORE. R. O. Dannenberg, Laird Crocker, and D. W. Bridges (Bureau of Mines. Salt Lake City Metallurgy Research Center). Dec. 1963. 35p.

Preliminary solvent extraction studies have been continued and expanded to improve on the previous estimate of process requirements. The solvent extraction portion of the process was examined at a scale large enough to enable meaningful extrapolation of the results to geometrically similar equipment of plant size. About 82 pct of the beryllium was recovered from approximately 0.5 pct beryllium oxide (BeO) Spor Mountain, Utah, ore by a process involving (1) sulfuric acid leaching, (2) countercurrent decantation (CCD) washing, (3) iron(III) reduction by sodium hydrosulfide (NaHS), (4) beryllium solvent extraction by di-2-ethylhexyl phosphoric acid (EHPA), (5) caustic stripping of beryllium-bearing EHPA, (6) hydrolysis of sodium beryllate-caustic strip liquor, and (7) calcination of beryllium hydroxide ($Be(OH)_2$) formed in step (6). The resulting beryllia assayed 98 to 99 pct BeO and was suitable for most non-nuclear uses. Best overall results were obtained by using pH 2, 1.6 grams of BeO per liter of leach liquor as feed and 0.25 N EHPA in kerosene containing 2 wt vol pct (grams per 100 ml of solution) isodecanol (IDA) as solvent. Analysis of the data indicated that a commercial plant would achieve 95-pct overall extraction operating at 45°C with 20 hp per 1,000 gal of dispersion in each of seven mixer-settlers, having 290 gal per ton of ore hourly mixer capacity and 90 gal per ton of ore hourly settler capacity. At least 79 lb $H_2SO_4$, 13 lb sodium hydroxide (NaOH), 3 lb NaHS, 0.25 lb kerosene, 0.07 lb polyacrylic flocculant, 0.03 lb EHPA, and 0.007 lb IDA would be required in $H_2SO_4$ leaching and subsequent processing to recover 1 lb BeO. (auth)

**27614** (IDO-14637) EFFECT OF RECIRCULATION OF DISSOLVER EFFLUENT ON THE CONTINUOUS DISSOLUTION OF ALUMINUM IN MERCURY-CATALYZED NITRIC ACID. R. H. Ray (Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho). Apr. 24, 1964. Contract AT (10-1)-205. 18p.

Catalyst requirements in the continuous dissolution of aluminum in nitric acid were reduced significantly in a pilot plant dissolver by recirculating the dissolver effluent. At simulated plant conditions, the recirculation of dissolver effluent allowed the concentration of mercuric nitrate catalyst to be reduced by a factor of 3.2. Natural recirculation operation, demonstrated to be effective in the pilot plant, is recommended for the full-scale dissolvers in the Idaho Chemical Processing Plant in order to reduce the catalyst requirements. (auth)

**27615** (MITNE-43) EQUILIBRIUM EXTRACTION CHARACTERISTICS OF ALKYL AMINES AND NUCLEAR FUELS METALS IN NITRATE SYSTEMS. Progress Report XII, January 1–September 31, 1963. Philip J. Lloyd and Edward A. Mason (Massachusetts Inst. of Tech., Cambridge). Dec. 2, 1963. For Oak Ridge National Lab., Tenn. Contract W-7405-eng-26, Subcontract 1327. 31p.

Using radiotracers, the distribution of mercury, antimony, and selenium between nitric acid and trilaurylamine in toluene was studied as a function of nitric acid and amine concentration. There was no significant effect of time of contact in the range 2 to 24 hours. Mercury showed a maximum extraction coefficient of ~1, selenium of ~0.1, and antimony of ~0.005, all at 0.1N nitric acid concentration, and 0.32M amine in toluene. The effect of nitric acid concentration was similar in each case, minima being observed at ~5M nitric acid. In an attempt to elucidate the chemistry of uranium extraction, a careful study was made of the system $UO_2(NO_3)_2$–$NH_4NO_3$–$HNO_3$–$H_2O$–TLA–$C_6H_5CH_3$ at varying uranium, amine, and nitric acid concentrations and constant nitrate concentration. It was found that for every uranyl ion transferred to the organic phase, two nitrate ions were also transferred; that the number of amine nitrate molecules associated with each extracted uranyl ion varied between 2 and 4, depending on the amine and acid concentrations; and the only available hydrogen ions in the organic phase were those due to hydrolysis of the amine nitrate and those of the unbound nitric acid. Based on these results and on the observation that in xylene, trilaurylamine nitrate exists in both monomeric and polymeric forms, where the polymers are almost entirely dimers, a model of extraction was proposed in which the uranyl nitrate was solvated by both amine nitrate monomers and dimers, and in which the free amine nitrate concentration available for taking part in the monomer-dimer equilibrium and subsequent extractions, was reduced by the extraction of unbound nitric acid. A study of the extractable complexes of ruthenium was begun. It was found impossible to determine the unbound nitric acid in the organic phase by titration due to reaction of the alkali titrant with the extracted ruthenium. However, it was found that the conductivity of the organic phase was a function only of the unbound nitric acid content of that phase. Using this, it is supposed that it will be possible to calculate the number of nitrate ions associated with the ruthenium, and thus determine the number associated with each ruthenium species. (auth)

**27616** (NP-13932) BOTTOM INTERFACE CONTROL IN A PULSED COLUMN BY DIRECT AIR PURGE. R. De Witte and L. Geens (European Company for the Chemical Processing of Irradiated Fuels, Mol, Belgium). May 1963. 28p. (ETR-155)

The development done on the bottom interface detection in pulse columns by the direct air purge system is described and discussed. The best results were obtained with dip-tube diameters ranging from 3 to 8 mm in conjunction with a combination of an orifice and an air chamber as pulse damping device in the purge air tubes just below the Dp cell. The minimum dip-tube spacing in the decanter should be 350 mm, although 500 mm ensures a larger safe operation zone. The purge air flow rates should be as constant as possible. Recorder calibration is necessary as a function of the pulse variables, and for the lowest possible phase density difference which could exist in the unit prior to actual start-up of the column. The system can be recommended for plant use when the previous conditions are observed. (auth)

**27617** (NP-13997) VERDAMPFUNG EINIGER URANSPALTPRODUKTE IN WASSERSTOFF, STICKSTOFF UND SAUERSTOFF UND IHRE CHEMISCHE BESTIMMUNG (THESE). (Evaporation of a Uranium Fission Product in Hydrogen, Nitrogen, and Oxygen and Its Chemical Determination (thesis)). Erhard Roeder (Johannes-Gutenberg-Universität, Mainz). 1964. 107p.

Work was carried out to separate by evaporation and to chemically determine some elements, which appeared from uranium fission, in uranium oxides. The evaporation experiments were first carried out in a furnace with carrier gases of hydrogen, nitrogen, and oxygen. The results, however, were not very satisfactory. Therefore, an apparatus was developed, which allows such a high temperature as are produced in a high-frequency furnace. The evaporation experiments in this apparatus were carried out with carrier gases of hydrogen and nitrogen. The results were so favorable that in preparative representation even elements with very small fission yields could be taken into consideration. Evaporation of neutron-irradiated $^{235}U$-enriched uranium oxide was carried out and results were very good. (M.C.G.)

**27618** (ORNL-TM-833) USAEC-EUROCHEMIC ASSISTANCE PROGRAM. Progress Report for July–December 1963. E. M. Shank (Oak Ridge National Lab., Tenn.). May 1, 1964. Contract [W-7405-eng-26]. 74p.

The development, construction, process testing, and economic aspects of the Eurochemic radiochemical processing plant for processing irradiated fuels are summarized. Information is included on: administration, schedules, operation, equipment design and development, handling requirements, uranium and plutonium recovery, engineering flowsheets, waste processing, analytical procedures, building designs, installation developments, feed preparation, solvent extraction, Citriflex head-end process, product purification, instrumentation development, hazard evaluation, and research activities. (N.W.R.)

**27619** (ORNL-3596) ADAPTATION OF THE FUSED-SALT FLUORIDE-VOLATILITY PROCESS TO THE RECOVERY OF URANIUM FROM ALUMINUM–URANIUM ALLOY FUEL. M. R. Bennett and G. I. Cathers (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 20p.

Adaptation of the fused salt-fluoride volatility process to the recovery of uranium from aluminum-base enriched uranium fuel was studied. In this process, the uranium is recovered from spent aluminum-base reactor fuels by dissolution in fused fluoride salt by hydrofluorination, fluorination, and volatilization of uranium as $UF_6$, and, finally, purification of the product $UF_6$ in a sorption-desorption step. The adaptation consists in use of a fused salt system which has a high $AlF_3$ solubility within desirable temperature limitations, and which gives adequate dissolution or hydrofluorination reaction rates. The $KF–ZrF_4–AlF_3$ salt system was found to be satisfactory. Extensive dissolution or hydrofluorination rate studies were made of fuel in this salt on a laboratory scale to show the feasibility of the process. Two types of flowsheets were investigated. Process tests were also made to demonstrate the completeness with which uranium is volatilized from the dissolution salt as $UF_6$. Some of the chemistry involved as side reactions in the dissolution step were studied. This modified fluoride volatility process for aluminum-base fuels works well and seems to be amenable to scaleup. (auth)

**27620** (TID-20662) FIXATION OF CESIUM-137 BY SOIL CLAYS. Progress Report, 1963–64. (Connecticut. Agricultural Experiment Station, New Haven). Contract AT(30-1)-2955. 5p.

Sorption of Cs from a range of dilute solutions by a synthetic cation-exchange resin and by several clay minerals in the presence of competing cations was studied. The sorption of Cs from dilute solutions by some typical soils of Connecticut was also investigated. The sorption behavior of the soil clays is described in terms of their mineralogical composition using the exchange isotherms obtained with pure clay minerals. Selectivity functions for the clays were calculated. (M.C.G.)

**27621** SPECTROGRAPHIC CONTROL ANALYSIS IN THE PRODUCTION OF PURE HAFNIUM AND ZIRCONIUM. W. J. Price (Magnesium Elektron Ltd., Manchester, Eng.). Colloq. Spectros. Intern. 8th, Lucerne, Switz., 1959, 107-12(1960).

The spectrographic determination of hafnium in zirconium, zirconium in hafnium, and other impurities in these metals and their compounds is discussed with particular reference to the special problem of controlling a chemical plant for the separation of these two elements. For sensitivity down to 20 ppm, the use of a spectrum profiling apparatus (display comparator) is described. Both solution and solid electrode techniques were employed for assessing the purity of materials at different stages of the process. (auth)

**27622** U.S.A.E.C.'S BASIC RESEARCH OF CHEMICAL PROCESSES FOR THE RECOVERY OF SPENT FUEL ELEMENTS. Comit. Nazl. Energia Nucl., Notiziario, 10: No. 5, 42-5(May 1964). (In Italian)

The research work on chemical processing of spent fuel elements at the Oak Ridge National Laboratory, Los Alamos Scientific Laboratory, Savannah River Laboratory, Argonne National Laboratory, and the Idaho Center, each of which investigates a different kind of chemical treatment, is discussed. (auth)

**27623** SOLVENT EXTRACTION OF URANIUM(VI) FROM THORIUM(IV), ZIRCONIUM(IV), OR TITANIUM(IV). Badri V. Agarwal, Satendra P. Sangal, and Arun K. Dey (Univ. of Allahabad, India). J. Indian Chem. Soc., 41: 119-21(Feb. 1964).

A method is described for the separation of U(VI) from Ti(IV), Zr(IV), or Th(IV), using sodium diethyldithiocarbamate as a complexing agent and n-butanol for solvent extraction. Uranium was determined spectrophotometrically; 2.35 to 9.4 mg of U can be separated from 2.39 to 9.52 mg of Ti, 4.56 to 18.24 mg of Zr, or 70 to 280 mg of Th at pH 2.0. The pH range in which the separation can be carried out successfully was found to be 1.5 to 3.0. The presence of the following ions interfere: Cu(II), Fe(II), Fe(III), Co(II), Ni(II), Bi(III), Cr(VI), Mo(VI), W(VI), Te(IV), Se(IV), Ag(I), Pb(II), Hg(II), Zn(II), Cd(II), Mn(II), In(III), Tl(I), As(III), Sn(IV), Os(VIII), Nb(V), and V(V). (auth)

**27624** THE ECONOMIC ASPECTS OF CHEMICAL REPROCESSING OF IRRADIATED NUCLEAR FUEL. Vaclav Kourim and Milan Marhol (Inst. for Nuclear Research, Czechoslovak Academy of Sciences, Rez). Jaderna Energie, 10: 157-64(May 1964). (In Czech)

Some economic problems in the reprocessing of irradiated nuclear fuel were considered from chemical aspects. Literature sources (63) up to the third quarter of 1962 were used. (auth)

**27625** EXTRACTION OF U(VI) BY n-TRIOCTYLAMINE (TOA) IN THE PRESENCE OF VARIOUS CATIONS. I. NITRIC ACID SOLUTIONS. V. I. Tikhomirov, A. A. Kuznetsova, and E. D. Batorovskaya. Radiokhimiya, 6: 173-81(1964). (In Russian)

Extraction of uranium(VI) by n-TOA from nitric acid solution was studied. The presence of nitrates of various metals in the aqueous phase resulted in a salting-out effect on the extraction of the uranium by $TOA \cdot HNO_3$ in chloroform. The effect was greater the more concentrated the cation of the salting-out agent. The order of the salting-out effect was $Li > Na > NH_4 > K$. For the divalent cations the order was $Mg > Co > Ni > Zn > Cd > Ca > Sr$. The order of magnitude of cation radii was almost the same. In spite of the similar crystallo-chemical radii of $Ni^{2+}$, $Co^{2+}$, and $Mg^{2+}$, nickel and cobalt were more effective salting-out agents. This was possibly due to the higher covalent interaction of the nickel and cobalt with neighboring molecules. The effectiveness of the salting-out agent increased with increasing charge on the cation. The effect of the nature of the salting-out-agent cation was less clear with increasing acidity of the aqueous phase. With nitrate concentrations greater than 7 to 9 g-ions per liter, independently of the nature of the cation of the salting-out agent and the nitric acid concentration, a decrease in the distribution coefficient was observed. (TTT)

**27626** EXTRACTION OF U(VI) BY n-TRIOCTYLAMINE (TOA) IN THE PRESENCE OF VARIOUS CATIONS. II. HYDROCHLORIC ACID SOLUTIONS. V. I. Tikhomirov, A. A. Kuznetsova, and F. D. Batorovskaya. Radiokhimiya, 6: 182-7(1964). (In Russian)

Data are presented on extraction of uranium(VI) by TOA·HCl in chloroform from aqueous potassium, ammonium, sodium, lithium, strontium, calcium, magnesium, and aluminum chloride solutions. Extraction was enhanced by the presence of chloride. The salting-out effect of the monovalent cations was in the order K < $NH_4$ < Na < Li, and that of the divalent, Sr < Ca < Mg. With lithium and magnesium ions, which have similar crystal structures, the salting-out effect increased with increasing ion charge, and the salting-out effect of aluminum was higher than that of magnesium. The distribution coefficient also increased with increasing chloride concentration or with increasing hydrochloric acid concentration in the aqueous phase. Extraction of acid was maximum from 8M hydrochloric acid. A decrease in the distribution coefficient at very high concentrations of the salting-out agent may be due to higher extraction of hydrochloric acid into the aqueous phase, with a resulting decrease in free extractant. Actually, under these conditions, uranium(VI) may be transferred from the organic to the aqueous phase, which is related to an increased rate of the ion exchange process. The dependence of the distribution coefficient on the concentration, charge, and radius of the cation of the salting-out agent was similar to that reported for nitrate systems, but the nature of the cation is less important. (TTT)

**27627** EXTRACTION OF U(VI) BY n-TRIOCTYLAMINE (TOA) IN THE PRESENCE OF VARIOUS CATIONS. III. SULFURIC ACID SOLUTIONS. V. I. Tikhomirov, A. A. Kuznetsova, and E. D. Batorovskaya. Radiokhimiya, 6: 187-91(1964). (In Russian)

The addition of sulfate to an extraction system, regardless of the nature of the cation of the salt, decreased the uranium distribution coefficient, and the salting-in effect increased with increasing acidity of the solution. The distribution coefficient was somewhat dependent on the radius of the cation, being higher in the presence of lithium than in sodium or ammonium; the ionic radii are 0.78, 0.98, and 1.43, respectively. The cation valence had only a slight but irregular effect, with lithium slightly more effective than aluminum, which in turn was slightly more effective than magnesium from 2N sulfuric acid. From 1N sulfuric acid, the order was different. In the presence of sodium sulfate the acid content in the organic phase was less than with magnesium and aluminum present. Comparison of these data with those on extraction of uranium(VI) by this reagent from nitric and hydrochloric acid solutions showed that the effect of the nature of the cation of the salt was less clear than the tendency to complex formation with the uranyl ion. However, the degree of extraction from dilute hydrochloric or nitric acid solutions was very low and increased with increasing concentration of the anions since relatively high concentrations were used for complex formation. The cation acidity was also effective toward an increase in the concentration of uranyl ion complex and therefore toward an increase in the distribution coefficient. (TTT)

**27628** COMPLEX FORMATION OF TRIVALENT PLUTONIUM WITH ACETATE, CITRATE, AND TARTRATE ANIONS BY AN ION EXCHANGE METHOD. A. I. Moskvin, V. P. Zaitseva, and A. D. Gel'man. Radiokhimiya, 6: 214-30(1964). (In Russian)

Formation of complexes by $Pu^{3+}$ in acetic, citric, and tartaric acids and the stability constants of the complexes were studied by an ion exchange method. The objective was to find conditions suitable for separating the trivalent actinides. The distribution coefficient of $Pu^{3+}$ in tracer amounts between 1M $NH_4Cl$ and the cation exchange resin KU-2 did not change significantly with a change in the pH from 1.2 to 3.2 in the absence of complexing agents. In the presence of $10^{-4}$M sodium acetate, above pH 7, $Pu^{3+}$ existed principally as an acetate complex, but at pH's below 3, complexes were absent. With an increase in the acetate concentration, sorption of $Pu^{3+}$ by the resin decreased, which indicated the formation of a complex with $Pu^{3+}$ in acetate solution. A mathematical treatment of the data indicated the formation of $[PuHAc]^{3+}$, $[Pu(Ac)]^{2+}$, $[Pu(Ac)_2]^{+}$, $[Pu(Ac)_3]^{0}$, and $[Pu(Ac)_4]^{-}$. Similar experiments indicated that in tartrate solutions the ions formed are $[Pu(H\ tart)]^{2+}$, $[Pu(tart)]^{+}$, and $[Pu(tart)_2]^{-}$ and in citrate solutions, $[Pu(cit)]^{0}$, $[Pu(H_2cit)_2]^{+}$, and $[Pu(H_2cit)_3]^{0}$. Comparison of the stability constants of the acetate, tartrate, and citrate complexes of $Pu^{3+}$ showed the order of readiness of complex formation to be $citrate^{3-} > tartrate^{2-} \approx acetate^{1-}$, which is in accordance with the increasing degree of dissociation of the acids. (TTT)

**27629** MAGNETITE AS A HIGH-TEMPERATURE ADSORBENT IN PRESSURIZED-WATER SYSTEMS. F. H. Sweeton and C. F. Baes, Jr. (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 158(June 1964).

**27630** PURIFICATION OF ORGANIC REACTOR COOLANTS. A. L. Kohl and C. A. Trilling (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 158-9(June 1964).

**27631** ON THE SEPARATION OF STRONTIUM AND CALCIUM IN THE RADIOCHEMICAL ANALYSIS OF SOILS. G. G. Glonti (Scientific-Research Inst. of Soil Science, Agricultural Chemistry and Land Improvement, Tbilisi, USSR). Zh. Analit. Khim., 19: 637-9(1964). (In Russian)

A study was made of the possibility of separating microamounts of strontium from considerably exceeding amounts of calcium by means of $K_4Fe(CN)_6$. It was established that radiostrontium can be almost quantitatively separated from macroamounts of calcium in a soil extract. Conditions are described for the rapid and accurate separation of strontium from soil samples. (auth)

**27632** THE EXTRACTION OF COMPLEX DIVALENT METAL CATIONS BY NAPHTHENIC ACID. Archibald William Fletcher (to National Research Development Corp.). British Patent 958,397. May 21, 1964. Filed July 13, 1961.

A process is given for the extraction of uranyl ions or their hydrolytic products from an aqueous solution. The process comprises contacting the solution with naphthenic acid in an inert organic solvent which is immiscible with the aqueous solution (e.g., kerosene), separating the organic extract, and stripping it with an acid. The pH of the aqueous solution before extraction should not be more than 0.5 of a pH unit below the pH of the hydrolysis. The aqueous raffinate may be extracted again for improved recovery. The effects of pH on the recovery are shown. (D.L.C.)

# ENGINEERING

## General

**27633** (DASA-1321) FEASIBILITY STUDY FOR A LARGE BLAST SIMULATOR. Final Report. Volume I. A. H. Wiedermann, J. J. Swatosh, Jr., and E. Guillard (Illinois Inst. of Tech., Chicago. IIT Research Inst.). Jan. 1964. Contract DA-49-146-XZ-064. 253p. (AD-427807)

The object of this research program is to determine the most feasible means of obtaining a nuclear blast simulator which will reproduce the transient flow field associated with the 500 psig overpressure range of large nuclear weapon detonations. The blast simulator is of the general purpose type and is characterized by a traveling shock wave followed by a flowing gas. The test section is of the order of 25 × 50 feet in section and contains, in addition to the gas flow region, a soil container or region in which air induced stress waves can be generated. Two concepts were considered the most feasible. One is the standard shock tube concept which consists of a long tube, closed at one end, in which explosives are distributed over a large region and detonated. The other is the space variable energy input shock tube concept which consists of a long tube, open at both ends, in which explosives are distributed in a non-uniform manner. The resulting detonation yields longitudinal pressure gradients which are similar to the wave forms of interest. Both of these concepts simulate the overpressure and dynamic pressure variation in the test section satisfactorily. Cost estimates for these two concepts were made for a variety of facility sizes and blast wave parameters. (auth)

**27634** (UCRL-7402) THERMALLY INDUCED VIBRATIONS OF CONCENTRIC THIN SPHERICAL SHELLS. Arthur L. Austin (California. Univ., Livermore. Lawrence Radiation Lab.). June 18, 1963. Contract W-7405-eng-48. 27p.

If a thin, unrestrained spherical shell is rapidly heated, large inertial hoop stresses are developed which result in free oscillation. It has been shown that the dynamic stress amplitude is dependent upon the ratio of heating time to the natural period of oscillation, as well as upon the maximum temperature. The dynamic response of a set of concentric spherical shells when the inner shell was subjected to rapid, uniform, internal heat generation was analyzed. The dynamic stresses were obtained for elastic motion and the case in which the outer shell was allowed to flow plastically at constant stress. The special case of instantaneous heating and the effect of composite material properties upon stress amplitudes were considered in detail in order to provide useful design formulas. (auth)

**27635** BENDING AND STRETCHING OF ELASTICALLY COUPLED CIRCULAR PLATES ON ELASTIC FOUNDATION. Zenons Zudans (Franklin Inst., Philadelphia). Trans. Am. Nucl. Soc., 7: 156-7(June 1964).

**27636** ULTRA-SOFT X-RAY SOURCE. Burton L. Henke (to Philips Electronics and Pharmaceutical Industries Corp.). U. S. Patent 3,138,729. June 23, 1964. Filed Sept. 18, 1961.

An improved x-ray tube is designed for producing long-wavelength x rays with good efficiency. The tube comprises a hollow metal member with a cylindrical cavity, and a filamentary cathode and an anode within this cavity. The target surface of the anode faces away from the cathode, and electrons are directed to the target surface by a deflection field between the anode and the cavity wall. A barrier electrode is provided to prevent electrons from going to the underside of the anode. The anode is operated at >300°C in order to prevent carbonaceous contamination. (D.L.C.)

## Applications of Nuclear Explosions

**27637** (RM-3884-PR) ELECTROMAGNETIC SIGNALS PRODUCED BY LOW-ALTITUDE NUCLEAR EXPLOSIONS. W. J. Karzas and R. Latter (RAND Corp., Santa Monica, Calif.). Dec. 1963. Contract AF49(638)-700. 27p. (AD-429404)

Electromagnetic signals from nuclear explosions at low altitude in the region ionized by the gamma rays are discussed. Specifically, a simplified model of an explosion is treated analytically. The model assumes the explosion takes place at a height h above an infinitely conducting ground. The ambient air is assumed to have a uniform and constant conductivity, and the explosion is approximated as a point source of gamma rays. This model is solved analytically for the magnetic field at any point about the explosion. Some numerical results illustrate the time and space variation of the magnetic field. (auth)

**27638** (UCRL-7801) DEPOSITION OF THERMAL ENERGY BY NUCLEAR EXPLOSIVES. R. A. Heckman (California. Univ., Livermore. Lawrence Radiation Lab.). Apr. 6, 1964. Contract W-7405-eng-48. 23p. (CONF-470-9)

From the 3rd Plowshare Symposium on Engineering with Nuclear Explosives, Davis, Calif., Apr. 1964.

A fraction of the energy released by the underground detonation of nuclear explosives is locally deposited as residual thermal energy. An accurate prediction of this usable fraction of the energy released is necessary to evaluate the feasibility of several of the proposed projects in the Plowshare Program. Analysis of dynamic temperature distribution data derived from experimental measurements in three different geological media; tuff, granodiorite, and salt, indicates that the distribution of residual thermal energy several months after detonation may be deduced from currently available computer-code predictions of the energy distribution at very early times. However, the actual fraction of energy remaining is strongly dependent on the degree of containment achieved during the nuclear detonation. In addition, the thermodynamic quality of the residual heat energy is directly a function of the total water content of the medium in which the detonation takes place. (auth)

**27639** (FTD-TT-63-1061) NUCLEAR WEAPONS AND THEIR EFFECTS. Kurt Langhans. Translation of "Kernwaffen und Ihre Wirkungen" (a publication of the Ministry of Interior, Berlin, 1963). 165p.

Nuclear weapons are classified as nuclear fission weapons, nuclear fusion weapons, three-phase nuclear weapons; and radioactive warfare agents. Means for delivery and detonation of each type are discussed. Data are summarized on the effects of nuclear weapons. Methods for protection against nuclear weapons are outlined. (50 references.) (C.H.)

## Facilities and Equipment

*Refer also to abstract 27755.*

**27640** (CEA-R-2418) ESSAIS DE POMPES POUR LIQUIDES CHARGES. (Tests on Pumps for Charged Liquids). Jean-Claude Moroni and Andre Niver (France. Commissariat a l'Energie Atomique. Centre du Production de Plutonium de Marcoule, Chuscian). Apr. 1964. 17p.

The pumps intended for the circulation of charged and radioactive liquids have particular qualities. The choice of such a pump has called for endurance tests with various types of equipment: a Goodyear volumetric screw pump; and Richier, Klein, and Schabaver centrifugal pumps. The latter, fitted with a special gland, gave the best results. (auth)

**27641** (NP-13726) AN EXPERIMENTAL INVESTIGATION OF LEVEL MEASUREMENTS BY AIR-PURGED DIP-TUBES. J. Challe and R. Freiwald (European Company for the Chemical Processing of Irradiated Fuels, Mol, Belgium). July 1963. 39p. (ETR-152)

The main causes of error inherent in the level detecting system that was adopted for the Eurochemic Plant are discussed. The dynamic behavior of air-purged dip-tubes was investigated. Conclusions were drawn on the basis of the experimental data given. (auth)

**27642** (ORNL-tr-118) LIQUID MIXING IN NARROW BUBBLE COLUMNS. W. Siemes and W. Weiss. Translated for Oak Ridge National Lab., Tenn., from Chem.-Ing.-Tech., 29: 727-32(1957). 21p.

The mixing of a liquid (water) by rising air bubbles was measured in a narrow column (42 mm diameter). The time dependence of the concentration was followed at one point by conductivity measurements after an electrolyte was injected at another point. The process was treated as mathematically analogous to diffusion, and mixing coefficients (replacing diffusion coefficients) were determined. These coefficients depend upon the bubble size and gas throughput. (D.C.W.)

**27643** (UCRL-13082(Rev.I)) HOT GAS POWER SUPPLY SYSTEM DEVELOPMENT PROGRAM FOR LAWRENCE RADIATION LABORATORY. AIRESEARCH PART 120342-1-1. R. W. Gazzera and K. W. Hoffner (Garrett Corp. AiResearch Mfg. Div. of Airzona, Phoenix). Apr. 30, 1964. Contract [W-7405-eng-48]. 80p.

The successful development and evaluation of a hot gas motor and integral solid propellant energy source weighing 0.80 pounds and nominally rated at 1.75 hp at 18,600 rpm is reported. The actuator assembly is considered to be completely developed and ready for production. Minor product improvements are recommended for incorporation in the unit at the time of production. (auth)

**27644** (WAPD-TM-399) A DIGITAL PROGRAM TO DETERMINE THE OPERATIONAL CHARACTERISTICS OF A PILOT-ACTUATED WATER-RELIEF VALVE—BETTIS CODE M0317. D. D. Schultz (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). May 1964. Contract NObs-90029. 47p.

An analysis of the dynamics of a pilot-actuated water-relief valve and the pressure-relief system during a pressure transient is presented. The developed equations were programmed for the Philco-2000 digital computer in FORTRAN as Bettis code M0317. The input of the code consists of the valve, the system, and the pressure transient characteristics. The output of the code includes the variation of pressures, flowrates, and valve lift with respect to time. (auth)

**27645** STRIP CONDUCTORS. T. H. Beeforth (Mullard Research Labs., Surrey, Eng.). Ind. Electron., 744-6(Nov. 1963).

Charts are presented, together with the underlying relations, for designing current-carrying strip conductors for producing magnetic fields of desired amplitudes with either 75 or 90% uniformity. For high-frequency applications, the strip impedance is introduced as an additional design parameter. More complex systems are briefly considered. (D.C.W.)

**27646** NASA SPACE PROPULSION FACILITY. Wallace J. Dodson (Kaiser Engineers, Oakland, Calif.). Trans. Am. Nucl. Soc., 7: 69-70(June 1964).

**27647** SOME METALLURGICAL CONSIDERATIONS IN THE DESIGN AND OPERATION OF LIQUID-METAL SEALS. B. Blumenthal, L. R. Kelman, and H. V. Rhude (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 190(June 1964).

**27648** PIPE CONNECTORS (Engineering Materials). (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). (CAPE-1092)

This package contains 27 drawings. For a listing of individual titles, see the Engineering Materials List (TID-4100). The Hanford jumper pipe connectors are used for vertical and horizontal arrangements and include 1, 2, 3, and 4 in. sizes. Drawings are included of a remotely operated impact wrench and dust caps to be placed over unused cell pipe connections. (F.S.)

**27649** DISASSEMBLY AND DECONTAMINATION APPARATUS ESPECIALLY FOR CALUTRONS. Albert Simon (to Commissariat a l'Energie Atomique). British Patent 960,751. June 17, 1964. Priority date Nov. 29, 1961, France.

An apparatus is designed for carrying out the operations involved in handling a radioactive calutron vessel, e.g., chemical washing and reconditioning of the vessel. The apparatus comprises a leakproof casing with glove holes and inspection windows, which is pivotally mounted on a horizontal shaft and has a coupling station for receiving the vessel which is to be disassembled and decontaminated. The operation of the apparatus is described. (D.L.C.)

**27650** EXTRACTION HEAD FOR WITHDRAWING A RADIOACTIVE THREAD OR WIRE. Micheil Mourain (to Commissariat a l'Energie Atomique). British Patent 961,016. June 17, 1964. Priority date May 11, 1962, France.

An extraction head is designed for withdrawing and transporting radioactive thermocouples or similar wire-like elements from hot cells. The head comprises a shielding body with a central cavity and a tube projecting radially from the cavity, a device for winding the wire within the cavity, and means for ejecting the wound wire into a storage receptacle. (D.L.C.)

## Heat Transfer and Fluid Flow

*Refer also to abstract 27663.*

**27651** (AE-141) HEAT TRANSFER AND PRESSURE DROP WITH ROUGH SURFACES. A LITERATURE SURVEY. Ajay Bhattacharyya (Aktiebolaget Atomenergi, Stockholm). May 1964. 78p.

This literature survey deals with changes in heat trans-

fer coefficient and friction factor with varying nature and degree of roughness. Experimental data cover mainly the turbulent flow region for both air and water as flow mediums. Semiempirical analysis about changes in heat transfer coefficient due to roughness was included. An example of how to use these data to design a heat exchanger surface is also cited. The extreme case of large fins was not considered. Available literature between 1933 and 1963 was covered. (auth)

**27652** (COO-926-31) TWO-PHASE FLOW THROUGH APERTURES. H. S. Isbin (Minnesota. Univ., Minneapolis). [1967]. Contract AT(11-1)-926. 13p. (CONF-537-1)

From USAEC-EURATOM Conference on Two Phase Flow Problems, Washington, D. C., Apr.-May 1964.

Apertures are defined as any type of opening varying from sharp-edged orifices to tapered and contoured sections including short tubes (L/D < 4). The studies of two-phase, steam–water flows through apertures are aimed at acquiring a better understanding of the phenomena associated with "loss-of-coolant accidents" and the release rates of coolant from breaks in the reactor vessel and piping. Details of the flows in apertures are being investigated experimentally and are being coupled with analytical models to yield predictive methods. (auth)

**27653** (GEAP-4577) A PROGRAM OF TWO-PHASE FLOW INVESTIGATION. Fourth Quarterly Report, January–March 1964. F. W. Staub and N. Zuber (General Electric Co., Schenectady, N. Y.). Apr. 1964. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(04-3)-189. 62p. (EURAEC-1050)

Shakedown tests are described on equipment designed for studies of the thermal-hydraulic oscillations and instabilities of two-phase flows of $CHClF_2$. (T.F.H.)

**27654** (HW-80391(Rev.1)) COMPARISON OF BOILING BURNOUT DATA FOR 19-ROD BUNDLE FUEL ELEMENTS SPACED WITH "WIRES" AND "WARTS." J. M. Batch and G. M. Hesson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Jan. 1964. Contract AT(45-1)-1350. 24p.

Boiling burnout heat fluxes were determined for an electrically heated model of 19-rod bundle fuel elements using warts to maintain the 0.050-in. spacing between rods. The test section was 19½ in. long, and the spacers were located 6¼ in. from each end of the test section. The test section was identical in all respects to one used previously except that the earlier test section used wire wraps on 12 of the rods to maintain the rod spacing. The experiments were made at a pressure of 1200 psig and at mass velocities for 500,000 to 5,000,000 lb/hr-ft$^2$. Exit conditions ranged from enthalpies of 350 to 700 Btu/lb. Boiling burnout heat fluxes ranged from 270,000 to 1,600,000 Btu/hr-ft$^2$. The data show almost no difference between the boiling burnout heat fluxes of test sections using wire wraps or using warts for rod spacing. (auth)

**27655** (LA-3061) PARTICLE-TO-GAS HEAT TRANSFER IN FLUIDIZED BEDS. A. C. Juveland, H. P. Deinken, and J. E. Dougherty (Los Alamos Scientific Lab., N. Mex.). Jan. 1964. Contract W-7405-eng-36. 28p.

Particle-to-gas heat transfer measurements were made in shallow beds of ZrC particles fluidized by helium or argon. The particles were heated by induction to temperatures as high as 1150°C. Transfer coefficients were obtained using a steady state system from measurements of the temperature of the solids and the gas temperature downstream from the bed. Four different average particle sizes were used, ranging from 385 to 1420 μ. The static bed depth was varied from 0.18 to 1.31 cm. Reynolds numbers of from 0.23 to 84 were investigated. A qualitative argument for the low heat transfer coefficients in fluidized beds is presented. (auth)

**27656** (LA-3077) THE TWO-DIMENSIONAL HYDRODYNAMIC HOT SPOT. Charles L. Mader (Los Alamos Scientific Lab., N. Mex.). Mar. 24, 1964. Contract W-7405-eng-36. 94p.

The basic processes in the shock initiation of the detonation of inhomogeneous explosives are theoretically investigated using the model of a cylinder of nitromethane containing a spherical void. The interaction of a shock with a spherical void, the resulting formation of a hot spot, and build-up to propagation detonation were computed using two-dimensional numerical hydrodynamics of the particle-in-cell type with chemical reaction and realistic equations of state. (auth)

**27657** (NASA-SP-41(p.257-71)) PROBLEMS RELATED TO COMPATIBILITY TESTING. A. HEAT TRANSFER AND FLUID FLOW (BOILING STABILITY). Paul A. Lottes (Argonne National Lab., Ill.).

Boiling instability leads to flow oscillations, pressure surges, and temperature excursions which complicate corrosion testing. Relations describing a boiling fluid flow system are discussed and the behavior of two-phase flow systems examined. It is concluded that there are two types of boiling instability related to multivalued pressure drops and momentum changes, respectively. In order to prevent such instabilities, the boiling system should be provided with a high head pump, an inlet orifice, a large vapor volume, and no compressible gas spaces between the pump and the heated channel. (D.L.C.)

**27658** (PWAC-401(Pt.II)) LCRE VALVE DEVELOPMENT. Final Report. Donald E. Smith (Pratt and Whitney Aircraft Div., United Aircraft Corp. Connecticut Aircraft Nuclear Engine Lab., Middletown). May 4, 1964. Contract AT(30-1)-2789. 35p.

The Lithium-Cooled Reactor Experiment required liquid metal valves capable of 10,000-hour operation in NaK and lithium at maximum temperatures of 1200 and 1000°F, respectively. To arrive at valve designs compatible with this liquid metal service, a development program of component and valve assembly tests was initiated. Approximately 38,000 hours of liquid metal testing was accumulated on a total of 11 valves prior to the termination of the program. (A chronological summary of testing on these valves is presented.) Over 10,000 hours of this time was accumulated on isolation type valves in the NaK circuit of the Non-Nuclear System Test which is currently in operation. Type 316 stainless steel valves, representative of both the primary and secondary system designs, were exposed to lithium and NaK, respectively, with no evidence of self-welding or liquid metal attack. A secondary system valve was endurance-tested in NaK for 10,000 hours at temperatures to 1500°F. Primay system valves representing fill-and-drain, punch, and throttle designs were tested for periods to 4000 hours at a maximum lithium temperature of 1000°F. Bellows selected for the valve stem seal were cycled to failure at simulated system pressures and temperatures. The useful life prior to failure was, in all cases, far in excess of the 400 cycles specified for the LCRE. Punch valve diaphragms of 25-mil thick type 316 stainless steel sheet were successfully tested for 10,000 hours at 1000°F in lithium with no evidence of leakage. Improved lapping techniques reduced seat leakage rates from

over 200 cubic centimeters per day to approximately 15 cubic centimeters per day. (auth)

**27659** (AEC-tr-6401) CRITICAL HEAT LOADS AND HEAT TRANSFER FOR A FORCED FLOW OF WATER IN TUBES IN THE REGION OF SUPERHIGH PRESSURES (175-220 ATM). A. P. Ornatskii (Ornatskiy). Translated for Westinghouse Electric Corp., Pittsburgh, from Teploenerg., 10: No. 3, 66-9(1963). 9p.

The results of an experimental investigation of the dependence of the critical heat load and the wall temperature of a tube (ID = 2 mm) on the mass flow rate, subcooling, and water pressure in the region of superhigh pressures are presented. The limits of "degeneration" of heat-transfer crisis are established for the experimental conditions. (auth)

**27660** (AEC-tr-6402) INVESTIGATION OF TRUE STEAM CONTENT IN A CIRCUIT WITH NATURAL CIRCULATION OF WATER. I. V. Kazin. Translated for Westinghouse Electric Corp., Pittsburgh, from Teploenerg., 10: No. 6, 25-9(1963). 9p.

The true steam content distribution in the riser branch of a circuit with natural circulation of steam–water was investigated. The branch consists of a riser channel with a bundle of heat-exchange rods washed by a longitudinal ascending flow of water and a round riser pipe in which adiabatic flow of the steam–water mixture takes place. The steam content was determined by irradiating the setup with gamma rays. (R.E.U.)

**27661** (AEC-tr-6414) HEAT TRANSFER COEFFICIENT IN THE REGION OF TRANSITION FROM CONVECTION TO BOILING DURING THE FORCED MOVEMENT OF LIQUID IN CHANNELS. A. A. Ivashkevich. Translated for Westinghouse Electric Corp., Pittsburgh, from Teploenerg., 10: No. 10, 76-8(1963). 8p.

A method is proposed for determining the heat transfer coefficient in the transition region between convection and boiling. An equation for this coefficient is derived by analyzing the experimental data. The equation is compared with the experimental data of various investigators. (auth)

**27662** (ORNL-tr-108) CRITICAL BOILING POINT IN THE FLOW OF 96% ETHYL ALCOHOL UNDER LOW HEATING CONDITIONS. P. I. Povarnin. Translated by A. L. Monks (Oak Ridge National Lab., Tenn.), from Teploenerg., 9: No. 12, 57-63(1962). 8p.

Results are given of measurements of the critical heat current when 96% ethyl alcohol flows through tubes. An empirical formula is proposed for $q_{cr}$ and a criterional equation was derived to calculate $q_{cr}$ under forced flow conditions and when the heat carrier is heated to $t_{boil}$. (auth)

**27663** RESIDUAL HEAT TRANSFER CAUSED BY DECAY OF FISSION FRAGMENTS. M. E. Minashin. Inzh. Fiz. Zh., 7: No. 2, 51-61(Feb. 1964). (In Russian)

Beta decay of fission fragments of $^{235}U$ is discussed. The values of total energy of fragments E = 21.24 Mev, and average kinetic energies of $\gamma$ quanta, electrons, and neutrons are obtained. With the results obtained and using statistical methods and time relation of fragment energy one determines the afterheat power for any moment $N_{fr}(i)$ and the rates of $\beta$ and $\gamma$ radiation. The results are compared with experimental data. The comparison shows good agreement. (auth)

**27664** FURTHER NOTES ON CONVERGENCE TECHNIQUES FOR IMPLICIT NUMERICAL SOLUTION OF THE DIFFUSION EQUATION FOR TRANSIENT HEAT TRANSFER. B. Kaplan and R. T. Poppe (U. S. Air Force, Wright Patterson AFB, Ohio). Trans. Am. Nucl. Soc., 7: 5-6 (June 1964).

**27665** LAMINAR FREE CONVECTIVE FLOW WITH TIME-DEPENDENT HEAT SOURCE. Keh C. Tsao and Rajender K. Arora (South Dakota School of Mines and Tech., Rapid City, S. Dakota). Trans. Am. Nucl. Soc., 7: 141-2(June 1964).

**27666** ON TWO-DIMENSIONAL FLUID MOTION THROUGH A SPOUT COMPOSED OF FOUR PLANE WALLS. Gordon C. K. Yeh (Space Technology Labs., Inc., Redondo Beach, Calif.). Trans. Am. Nucl. Soc., 7: 142-3(June 1964).

**27667** * BURNOUT- AND HEAT-TRANSFER CORRELATIONS FOR ONCE-THROUGH SUPERHEAT AT LOW FLOW WITH AN EXPONENTIAL SOURCE. E. E. Duke (General Dynamics Astronautics, San Diego, Calif.). Trans. Am. Nucl. Soc., 7: 143-4(June 1964).

**27668** CONVECTIVE HEAT TRANSFER OF GASES FLOWING ACROSS BUNDLES OF MULTI-START HELICAL TUBES WITH UNIFORM INCLINATION AND UNIFORM LONGITUDINAL PITCHES. P. V. Gilli (Waagner-Biro AG, Vienna). Trans. Am. Nucl. Soc., 7: 144-5 (June 1964).

**27669** TEMPERATURE DISTRIBUTION IN COMPOSITE CYLINDERS WITH ARBITRARY INTERNAL HEAT GENERATION AND NON-UNIFORM CIRCUMFERENTIAL HEAT REMOVAL. R. Katz and G. Melese (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Trans. Am. Nucl. Soc., 7: 146(June 1964).

**27670** HYDRAULIC INSTABILITY OF FLAT PARALLEL PLATE ASSEMBLIES. R. J. Scavuzzo (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 146-7(June 1964).

**27671** A METHOD OF PREDICTING STEAM-SURGE-TANK TRANSIENTS BASED ON ONE-DIMENSIONAL HEAT SINKS. Dannie J. Gorman and Eugene E. Drucker (Syracuse Univ., N. Y.). Trans. Am. Nucl. Soc., 7: 147-8(June 1964).

**27672** SYSTEM PRESSURE EFFECT ON TRANSIENT RESULTS OF THE STEP LOSS-OF-COOLANT TESTS. C. E. Parks and S. H. Esleeck (Babcock and Wilcox Co., Lynchburg, Va.). Trans. Am. Nucl. Soc., 7: 159(June 1964).

**27673** VOID-FRACTION MEASUREMENTS IN A CAVITATING MERCURY VENTURI. F. G. Hammitt, W. Smith, I. E. B. Lauchlan, R. D. Ivany, and M. J. Robinson (Univ. of Michigan, Ann Arbor). Trans. Am. Nucl. Soc., 7: 189-90(June 1964).

**27674** GAS/SOLIDS SUSPENSION CIRCULATOR DESIGN FOR 600 F, 150 lb/in.$^2$. James P. Waggener (Franklin Inst., Philadelphia). Trans. Am. Nucl. Soc., 7: 192-3(June 1964).

**27675** SOME PROBLEMS IN THE THEORY OF HEAT CONDUCTION FOR WEDGE-SHAPED BODIES. N. N. Lebedev and I. P. Skal'skaja (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Tekhn. Fiz., 34: 801-8(May 1964). (In Russian)

A method is proposed for the solution of a class of nonstationary problems in the theory of heat conduction for wedge-shaped bodies, based on the use of an integral transformation. An exact solution is obtained for the problem of the cooling of an infinite wedge having an arbitrary angle of span $2\gamma$ and edges at a set constant temperature. For the value $2\gamma = \pi/n$ (n = 1, 2, ...) simple formulas

are found, going at n = 1 and n = 2 into the known solutions for a half space and a right-angle wedge. (tr-auth)

**27676** TURBULENT HEAT EXCHANGE IN A SLAB IN THE PRESENCE OF SUBLIMATION AND WITH POROUS FLOW OF VARIOUS GASES. Yu. V. Lapin. Zh. Tekhn. Fiz., 34: 913-25(May 1964). (In Russian)

The influence of various factors on friction and heat exchange in a turbulent boundary layer is considered on the basis of previous investigations of heat exchange of a flat slab with a gas current in the presence of porous flow of various substances. The results are generalized for the case of sublimation of material of a surface streamlined by a high-temperature gas current. A method, allowing the calculation of the equilibrium sublimation region and the corresponding surface temperature with and without heterogeneous chemical reactions in the boundary layer, is demonstrated. (M.J.T.)

**27677** THE MASS TRANSFER OF SINGLE, SOLID URANIUM SPHERES TO FLOWING MOLTEN CADMIUM IN LAMINAR AND TURBULENT FLOW. Elwood Dean Traylor. Thesis, Columbus, Ohio, Ohio State Univ., 1963. 292p.

The mass transfer of normal uranium to molten cadmium was studied in order to extend the present data on mass transfer in aqueous and metal systems and to test previous classical correlations as well as to propose others. The relative high density of molten cadmium as compared with water made possible the attainment of very high Reynolds numbers, and afforded the opportunity to extend the mass transfer data into an unknown area. A ½-inch diameter uranium sphere was used, and molten cadmium was pumped past the test spheres at different flow rates. Mass transfer coefficients were determined from weight losses of the test spheres. The cadmium-uranium system was chosen because it was possible in this system to operate in a temperature range in which uranium was the solid phase in equilibrium with the molten cadmium solution. The $J_d$ data and other derived correlations were compared with previous correlations and data for different systems. The driving force for mass transfer was varied for the uranium-cadmium system, and the mass fluxes were obtained and plotted versus the concentration and activity driving forces. Extrapolation of these curves to zero driving force yielded finite mass flux rates that were different from the zero value expected at the saturated condition. It is shown that neither attrition nor the activity data and activity driving force could account for the finite flux at zero driving force. Uranium spheres that were heat-treated showed random grain structures and yielded $J_d$ values about 2 to 5 times as high as spheres not heat-treated to give non-random structures. The skin friction, f/2, for spheres in organic liquids from Reynolds numbers of $10^2$ to $10^3$ and at a separate Reynolds number of $1.56 \times 10^5$ was 2 to 3 times as great as the $J_d$ for uranium-cadmium. The results of runs with artificially roughened spheres showed that the roughening produced no effect at a Reynolds number of 330. At a Reynolds number of $8.8 \times 10^3$ the $J_d$ for the roughened sphere was about 80% higher than for the smooth sphere. This could be attributed to the early onset of the tripping of the boundary layer. The exponent of the Schmidt number was determined at Reynolds numbers of 736 and 115. The exponent on the Schmidt number was determined to be approximately 0.60. However, the range of variation of the Schmidt number was only 60%. The results provide good evidence that the conventional mass transfer expressions can be used for liquid metal systems. (Dissertation Abstr., 24: No. 11, 1964).

**27678** PROCEEDINGS OF THE 1964 HEAT TRANSFER AND FLUID MECHANICS INSTITUTE, HELD AT UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA, JUNE 10, 11, 12, 1964. Warren H. Giedt and Salomon Levy, eds. Stanford, California, Stanford University Press, 1964. 283p. $8.75.

Mass transfer cooling, convective boiling, transient flow characteristics of natural-circulation loops, natural convection and stratification, heat transfer between convective spheres, free surface flow, steady-state crystallization in supercooled liquids, aerodynamic heating, turbulent MHD flow, hypersonic flow, transport coefficients for ionized gases, heat transfer in seeded flowing gas, constricted arc column growth, and ionization effects on gas flow and heat transfer in electric fields are discussed. Separate abstracts are prepared for 5 of the 17 papers presented. (C.E.S.)

*For abstracts of individual papers see: 27679, 27680, 27681, 28165, and 28166.*

**27679** CONVECTIVE BOILING WITH LIQUID POTASSIUM. H. W. Hoffman and A. I. Krakoviak (Oak Ridge National Lab., Tenn.). p.19-37 of "Proceedings of the 1964 Heat Transfer and Fluid Mechanics Institute." Stanford, Calif., Stanford Univ. Press, 1964.

Interest in boiling liquid metals has led to the investigation of the heat-transfer characteristics of potassium in forced-convection saturation boiling. Initial experiments were concerned with upflow through a vertical, circular tube and included the determination of the magnitude of the critical heat flux. Two boiler sections were used. The first was a large diameter (0.87-in.-ID) tube with a maximum heat flux capability of 40,000 Btu/hr · $ft^2$, while the second was a small diameter (0.325-in.-ID) channel with a design heat flux limit of 500,000 Btu/hr · $ft^2$. Stable operation was obtained only when vapor existed at the boiler inlet. The heat-transfer mechanism in this situation was interpreted as involving an annular flow with conduction through a thin liquid film on the wall followed by evaporation at the inner liquid-vapor interface. With the low-flux boiler, an additional mode of performance was observed. During some phases of operation, tube-wall temperature oscillations of very high amplitude (±125°F) occurred for fluxes well below the critical; these fluctuations persisted with regular period and magnitude over long periods of time. Detailed examination of these data, along with results from related experiments, indicated strongly that these oscillations existed in the presence of unexpectedly high liquid superheats. The magnitude of the liquid superheat required for bubble nucleation with potassium was studied in an independent experiment using a small natural-convection loop. The superheat for potassium against a commercial-finish type 347 stainless steel surface was found to exceed 300°F at the normal boiling temperature. In contrast, superheats of only 30°F were observed when the surface was treated so as to create a porous surface. Critical heat flux values were obtained by systematically decreasing the flow through the boiler in the forced-convection system while maintaining a constant heat input. The results range from about 32,000 Btu/hr · $ft^2$ at a mass flow of $1.5 \times 10^4$ lb/hr · $ft^2$ to slightly more than 350,000 Btu/hr · $ft^2$ at $10^5$ lb/hr · $ft^2$; exit qualities at the critical condition were generally in excess of 50%. For both test boilers, the critical heat flux data agreed well with values predicted by the dimensional correlation of Lowdermilk, Lanzo, and Siegel for water. It is pointed out, however, that the validity of this comparison is probably restricted to potassium in that, alone among the alkali metals, the pertinent thermodynamic and thermo-

physical properties of potassium are similar to those of water. (auth)

**27680** CONSTRICTED ARC COLUMN GROWTH. H. E. Weber (General Electric Co., Philadelphia, Penna.). p.245-59 of "Proceedings of the 1964 Heat Transfer and Fluid Mechanics Institute." Stanford, Calif., Stanford Univ. Press, 1964.

The growth of a constricted arc column from the cathode with coaxial gas flow is treated as a boundary layer using the integral equation approach. The electric power dissipation increases the gas enthalpy which diffuses radially outward into the flowing gas. The column boundary finally reaches the constrictor wall at some distance downstream of the cathode. This distance is shown to be directly proportional to mass velocity. At a given distance the arc column radius increases with current. After the arc column has grown to the diameter of the constrictor wall and both the enthalpy and velocity profiles become fully developed, the heat loss is balanced by the electrical power input at each axial position. Hence, the momentum and energy equations contain only the radial coordinate. For this fully developed flow, enthalpy and velocity profiles were obtained for air over the column radius by computer integration of the energy and momentum equations, using theoretical calculated transport and thermodynamic properties. The properties were experimentally verified by some researchers over limited ranges of temperature. Results are presented and compared with data on nitrogen. From the fully developed velocity profiles it was noted that the velocity profiles vary from almost linear at the highest centerline enthalpies of 2500 $R_gT_o$ (26,000°K) to a little fuller than parabolic at the lowest centerline enthalpy of 500 $R_gT_o$ (8,500°K). The velocity increases near the centerline because the constant diameter constrictor imposes a pressure gradient on the gas due to the decreased density in the growing arc column. The acceleration of the lower density gases is more rapid; therefore, the velocity increases with enthalpy near the centerline of the constrictor. In fully developed flow the centerline enthalpy may be expressed as a function of the radius and current at any pressure. Since, in the growing arc column changes in the axial direction are much smaller than in the radial direction, this relation among current, centerline enthalpy and column diameter was assumed locally true. This relation was utilized to integrate the integral energy equation axially. The integration results in a plot of column radius, $\delta$, as a function of axial distance parameter, $z = x\pi R^2/W$ (ratio of axial distance from cathode to average mass velocity) for various values of the current. These three parameters, $\delta$, z, and I completely describe the behavior of the growing arc column. The results are consistent with physical observations. (auth)

**27681** THE EFFECTS OF IONIZATION ON THE FLOW AND HEAT TRANSFER OF A DENSE GAS IN A TRANSVERSE ELECTRICAL FIELD. Henry R. Velkoff (AF Aero Propulsion Lab., Wright-Patterson AFB, Ohio). p.260-75 of "Proceedings of the 1964 Heat Transfer and Fluid Mechanics Institute." Stanford, Calif., Stanford Univ. Press, 1964.

An investigation of the effects of ion motion on the pressure drop and heat transfer of a gas flowing in a channel was undertaken. Air and other gases were ionized within the channel and an electrostatic field was applied normal to the flow direction. Increases in pressure drop and heat transfer of the order of 2 to 1 were found with the application of the field at ionization levels of the order of ion to $10^9$ neutrals. It was observed that the velocity profiles in the channel were distorted due to the action of the field. Extensive data are presented on the variation of friction factor, velocity profile, and heat transfer with ion current. (auth)

**27682** A CORRELATION FOR BOILING HEAT TRANSFER TO SATURATED FLUIDS IN CONVECTIVE FLOW. John C. Chen (Brookhaven National Lab., Upton, N. Y.). New York, American Society of Mechanical Engineers, 1963, Paper No. 63-HT-34, 11p. $1.00. (CONF-129-21)

From American Society of Mechanical Engineers, American Institute of Chemical Engineers 6th National Heat Transfer Conference and Exhibit, Boston, Aug. 1963.

An additive mechanism of micro and macro-convective heat transfer was formulated to represent boiling heat transfer with net vapor generation to saturated, nonmetallic fluids in convective flow. Two dimensionless functions, S and F, were introduced to account for the suppression of bubble growth due to flow and for the increase in convective turbulence due to the presence of vapor. S and F were obtained as functions of a two-phase Reynolds number and the Martinelli parameter, respectively. The correlation was tested with available data for water and organic fluids. Data from different sources which could not be correlated satisfactorily by existing correlations were shown to be quite well correlated by the one presently proposed. The average deviation between calculated and measured boiling coefficients for all data points from nine experimental cases was ±11 percent. (auth)

## Materials Testing

**27683** (HW-78321) CRITICAL ANGLE ULTRASONIC TESTS. Charles E. Fitch, Jr., Gene L. Waldkoetter, and Reed B. Jacob (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). July 16, 1963. Contract [AT(45-1)-1350]. 4p.

For ultrasonic entry angles equal to and exceeding critical there is a system of inhomogeneous boundary waves that propagate at the boundary accompanying the total reflection for acoustically dissimilar media. The use of the influence of the boundary waves on the incident and reflected wave relations in ultrasonic testing is discussed. A case is considered for liquid incident medium and metal reflecting medium. (R.E.U.)

**27684** (MIT-63TM8) CREEP AND FATIGUE CRITERIA FOR HIGH-TEMPERATURE TURBO-COMPRESSOR LOOP MATERIALS. R. L. Thorkildsen (Mechanical Technology Inc., Latham, N. Y.). Dec. 27, 1963. Contract DA-44-009-AMC-316(X). 187p.

An analysis of the problems of creep-fracture and fatigue is presented, with the emphasis on generating criteria for the design of a high-temperature closed-cycle turbocompressor loop. Recommendations are made for specific design equations that can be used to predict the effects of factors such as stress concentrations, temperature, mean stress, and cumulative damage on high- and low-cycle fatigue, thermal fatigue, and creep-fracture. A summary of design equations is given. A detailed critique of the subject, which serves as the basis for these recommendations is also given. 139 references. (auth)

**27685** A MEDIUM-SPEED TENSILE TESTING MACHINE AND SOME DYNAMIC DATA PRODUCED THEREBY. A. G. H. Anderson (Watertown Arsenal, Mass.). J. Appl. Polymer Sci., 8: 169-96(1964).

A pneumatic tensile tester, recently designed and built at Watertown Arsenal Laboratories, has a load capacity

of 15,000 lb and an idling speed of about 300 in./sec over a 3-in. stroke, at 500 psi nitrogen or one-third the allowable maximum pressure. Loads and strains may be recorded by oscillographs or oscilloscopes. The scope can be triggered through an electric circuit by an internal, automatic poppet valve in the main gasport. External, auxiliary diaphragm valves are actuated by solenoids. Excess energy of piston assembly, after a tensile rupture, is absorbed through rapidly damped oscillations between two air cushions at opposite ends of the cylinder. The machine is mounted on a carriage resting on springs and Barrymounts so that operation at full load transmits negligible vibrations to the floor. Weight of machine and carriage is 700 lb; base, 600 lb; and steel safety cabinet 400 lb. Short descriptions and a number of illustrations are presented that show typical actions of the machine and results of various tests recently performed on structural materials. (auth)

**27686** IRRADIATION SOURCES FOR THE NON-DESTRUCTIVE TESTING OF METALS. E. Becker. Technik (Berlin), 18: 793-9(Dec. 1963). (In German)

Physical properties of common irradiation sources used in the testing of metals, such as $^{60}Co$, $^{137}Cs$, $^{192}Ir$, and $^{170}Tm$ isotopes, and their application in the testing of steel were investigated. The defect detectability was determined and optimum wall thickness ranges for the individual isotopes were investigated. (Rev. Metal Lit., 21; No. 5, Mar. 1964)

**27687** PROBE HOLDER FOR HEAT EXCHANGER (Engineering Materials). (Oak Ridge National Lab., Tenn.). (CAPE-1137)

This package contains 2 drawings and 2 photographs. For a listing of individual titles, see the Engineering Materials List (TID-4100). The probe holder, or indexing mechanism gives controlled movement to a probe used in the ultrasonic evaluation of the brazed joints between the 0.5 in. OD INOR-8 heat exchanger tube (with a wall thickness of 0.042 in.) and the tube sheet or header. The joint serves as a sealant to prevent intermixing of incompatible liquids. The probe holder allows longitudinal scans with successive rotary indices, rotary scans with longitudinal indices, and smooth rotation of the probe about its axis. The probe is vertically indexed by ratchet action. Two data potentiometers drive a servo-recorder, which provides an x-y plot of nonbond indications. Two pins on the holder with the probe form a triangular arrangement giving stability to the apparatus during probe rotation, which is provided by a crank and worm gear mechanism. The housing of the probe is fabricated of brass but other parts are stainless steel. (F.S.)

**27688** TUBING TANK (Engineering Materials). (Oak Ridge National Lab., Tenn.). (CAPE-1138)

This package contains 14 drawings and 1 photograph. For a listing of individual titles, see the Engineering Materials List (Tid-4100). The tank includes mechanical equipment used in ultrasonic testing of tubing. The equipment holds the tubing straight as it is rotated around its axis, keeps the transducer in proper alignment, and translates the transducer along the length of the tube at a rate that permits the sound beam to cover and test the surface of the tubing. The tank accommodates all normal tubing lengths and provides racks for material handling on the tank sides. A motor mounted at one end, operated by a variable speed control, is coupled to a gear reducer, which chain drives a data potentiometer, which provides the rotational signal to the "B" scan, a spindle mounted on a Jacobs chuck, and a second gear reducer. The second gear reducer rotates a sprocket which moves an endless roller chain extending the length of the tank. Reinforced plastic guide plates attached at intervals to the chain give support and steadying force to the tubing during inspection. A scanning dolly is mounted on the chain, which holds the ultrasonic search tube and the transducer. Two face plates are attached to the scanning dolly for additional steadying for small diameter tubing. A tailstock prevents excessive whip of the tube in rotation. As the tubing is rotated, the scanning dolly and transducer are translated along the length of the tubing at a definite ratio of rotation to linear speed that is controlled by the gear reducer and sprocket. (F.S.)

**27689** NON-DESTRUCTIVE ESTIMATION OF CEMENT CONTENT OF HARDENED CONCRETE. B. Vedat Enuestuen, Sevim Urkan, H. Seha Sentuerk, and Kayihan Koeksal. 13p. (CONF-433-5)

From American Society Testing Materials, 1964 International Conference on Materials, Philadelphia, Feb. 1964.

A method for estimating the cement content of hardened concretes by measurements of electrical conductance and neutron scattering was investigated. Estimates of 210 and 408 kg/m$^3$ with standard deviations of ±2 and ±3 kg/m$^3$, respectively, were obtained for blocks containing 200 and 400 kg/m$^3$ of cement. (D.C.W.)

## Protective Structures

*Refer also to abstract 27621.*

**27690** (NRL-TR-43) ATTENUATION OF FALLOUT RADIATION AS A FUNCTION OF CONCRETE BLOCKHOUSE WALL THICKNESS. Murray A. Schmoke and Ralph E. Rexroad (Army Nuclear Defense Lab., Edgewood Arsenal, Md.). Oct. 1963. 103p. (AD-431063)

An experiment was conducted to verify theoretical calculations of wall thickness effect on the shielding characteristics of a concrete blockhouse located in a uniformly contaminated fallout field. Two gamma emitters, cobalt-60 and cesium-137, were used to simulate uniformly contaminated fallout fields. The dose rates at various locations within the blockhouse were measured through wall thicknesses of 48 psf, 93.7 psf, and 139 psf with ionization-chamber dosimeters. Reduction factors were calculated from the data taken at the center detector positions and compared with reduction factors computed from theoretical calculations. (C.H.)

**27691** (R-425-PR) A REVIEW OF NUCLEAR EXPLOSION PHENOMENA PERTINENT TO PROTECTIVE CONSTRUCTION. H. L. Brode (RAND Corp., Santa Monica, Calif.). May 1964. Contract AF49(638)-700. 75p.

Specifically oriented to the design of protection from the effects of nuclear weapons, phenomena of the intense or close-in regions not always adequately covered in such otherwise thorough standard works as Glasstone's The Effects of Nuclear Weapons are discussed. Some features given emphasis are early fireball growth, prompt nuclear radiation near an explosion, cratering and intense ground shock, high-overpressure air blast, hot fireball air and intense thermal exposure, and distribution of debris and after-winds. The intention, however, was to include information on all aspects of nuclear explosions known to be pertinent to the design of shelters. (auth)

**27692** OPTICALLY ALMOST-FLAT DIFFUSION TRAPS OUT OF GLASS. J. S. Anderson (National Chemical Lab., Teddington, Middx, Eng.) and H. A. Kamphausen. Vakuum Tech., 12: 152-3(July 1963). (In German)

The use of optically flat diffusion traps in ultrahigh and

high vacuum technology was investigated. It was found that the closing obtained was not essentially better than that obtained with the ground-bulb trap; the simpler operation and greater possibilities of use of the flat trap, on the other hand, were more advantageous. (tr-auth)

## Vacuum Engineering

**27693** (ORNL-tr-149) A CONTRIBUTION TO THE ELECTRICAL ADSORPTION OF GASES AT VERY LOW PRESSURES. W. von Meyeren. Translated by Kenneth S. Warren (Oak Ridge National Lab., Tenn.), from Z. Physik, 84: 531-40(1933). 13p.

Described is research on the electrical adsorption of air and hydrogen in the pressure range of $10^{-4}$ to $10^{-6}$ mm Hg. The adsorption takes place in a hot cathode tube of special construction. For the attainment of a greater path traversed for the electrons and a higher electron density, there is provided within the tube a strong longitudinal magnetic field. By means of this arrangement, there takes place in the high vacuum a very strong gas ionization associated with an intensive gas adsorption. It was successful in reducing the gas pressure in a sealed two liter vessel from $10^{-4}$ to $10^{-6}$ mm Hg within a few minutes. (auth)

**27694** (ORNL-tr-150) A CONTRIBUTION TO THE ELECTRIC ADSORPTION OF GASES AT VERY LOW PRESSURES. PART II. W. von Meyeren. Translated by Kenneth S. Warren (Oak Ridge National Lab., Tenn.), from Z. Physik, 91: 727-36(1934). 12p.

Research on the electric adsorption of helium, argon, and nitrogen in the pressure range from $5 \times 10^{-4}$ to $1 \times 10^{-7}$ mm Hg is summarized. The adsorption takes place in a hot cathode tube with a ring anode and a longitudinal magnetic field. The adsorption process may be represented over a larger pressure area under special conditions by a simple exponential function. In an apparatus of 2.05 liters, a pressure of nitrogen of $1 \times 10^{-4}$ mm Hg may be reduced in a short time to $6 \times 10^{-7}$ mm Hg. (auth)

**27695** PROGRESS REPORT ON DEVELOPMENT OF DIFFUSION PUMP. Norman Milleron (Univ. of California, Livermore). Vakuum Tech., 12: 278-86(Dec. 1963). (In German). (UCRL-7505-T)

The development of a diffusion pump in a research program on controlled nuclear fusion is described. The properties of diffusion pumps are discussed and compared with other vacuum pumps. Construction criteria are outlined. The manner of operation, technical limits, and test results are discussed. (M.C.G.)

**27696** GASEOUS DESORPTION AT LOW PRESSURES AND LIQUID NITROGEN TEMPERATURES. D. M. Richardson and R. A. Strehlow (Oak Ridge National Lab., Tenn.). p.97-100 of "1963 Transactions. The Tenth National Vacuum Symposium, American Vacuum Society."

Desorption from a 30,000 $cm^2$ Mo surface at 80°K and $5 \times 10^{-10}$ torr was studied as a function of temperature increase to 115°K. Two distinct pressure peaks occurred on warming from the base condition, with desorption heats of 4.3 and 6.5 kcal/mole. The quantity of gas desorbed was much less than a monolayer. Heats of desorption measured for H, CO, Ar, and $CH_4$ were 2.2, 3.0, 3.5, and 4.3 kcal/mole. A Henry's law isotherm consistent with the data obtained is discussed relative to the achievement of better vacuum conditions for thermonuclear experiments. (auth)

# GEOLOGY AND MINERALOGY

## General

**27697** RADIOCARBON. Edward S. Deevey, Richard Foster Flint, and Irving Rouse, eds. Radiocarbon, 6: 1-376(1964).

Dates obtained by radiocarbon measurements at 29 laboratories are presented. (M.C.G.)

**27698** FISSION PRODUCT-SOIL ORGANIC MATTER COMPLEXES. I. STRONTIUM-90 (YTTRIUM-90) IN WATER EXTRACTS AND HCl HYDROLYSATES OF SOIL. J. L. Mortensen and E. C. Marcusiu (Ohio Agriculture Experimental Station, Columbus and Ohio State Univ., Columbus). Soil Sci. Soc. Am. Proc., 27: 653-6(Nov.-Dec. 1963).

Brookston silty clay loam was incubated with 40 $\mu$C $^{90}Sr(^{90}Y)$ for 60 days and extracted with hot water or hydrolyzed with 6N HCl. The supernatant liquid was centrifuged, concentrated, and subjected to electrodialysis, dialysis, gel filtration, and paper electrophoresis. Some $^{90}Sr(^{90}Y)$ and organic matter migrated to the anode compartment during electrodialysis suggesting the presence of low molecular weight, negatively charged $^{90}Sr(^{90}Y)$–organic matter complexes. Dialysis did not remove all of the $^{90}Sr(^{90}Y)$ from the extracts. Gel filtration separated the extracts into several organic-matter-containing components and showed that $^{90}Sr(^{90}Y)$ was complexed or held on exchange sites by high molecular weight polymers. Presence of radioactivity in the components was correlated with the presence of polyuronides. Phenols, $\alpha$-amino acids, and $\alpha$-keto acids were separated from the 6N HCl hydrolysate by paper electrophoresis, but no clear correlation between these components and radioactivity on the paper strips was obtained. (auth)

## Natural Radioactivity and Fallout

**27699** (A/AC.82/G/L-931) DETERMINACIÓN DEL ESTRONCIO 90 EN LECHES Y AGUAS DE LLUVIA. (Determination of Strontium-90 in Milk and Rainwater). A. M. Martínez, S. Bulbulian, and T. A. Brody (Mexico. Universidad Nacional Autónoma. Instituto de Física, Villa Obregon). 1964. 6p.

Data on the strontium-90 content of Mexican milk samples, covering the period from August 1961 to July 1963, and samples of collected rainwater, covering the period from September 1961 to October 1963, are presented. The method used was a variation of the chromatographic technique. (auth)

**27700** (LAMS-3071) BETA-GAMMA RADIOACTIVITY IN ENVIRONMENTAL AIR AT LOS ALAMOS, NEW MEXICO, FOR 1963. Jack W. Aeby and W. R. Kennedy (Los Alamos Scientific Lab., N. Mex.). Apr. 15, 1964. Contract W-7405-eng-36. 22p.

Airborne radioactive particulate matter was collected on filters and the filters were counted for $\beta$ activity 7 days after collection in a thin-window gas flow proportional counter. Results are reported for samples collected at the Los Alamos Scientific Lab., New Mexico, during 1963. (C.H.)

**27701** (NYO-2363-1) STRATOSPHERIC MONITORING PROGRAM SEMI-ANNUAL PROGRESS REPORT, SEPTEMBER 1963–FEBRUARY 1964. M. Lippmann, comp. (Del Electronics Corp., Mount Vernon, N. Y.). June 10, 1964. Contract AT(30-1)-2363. 70p.

Progress is reported on the design and testing of equipment for use in monitoring fallout in the stratosphere. Design features are described of a high-volume electrostatic precipitator aerosol sampler for use in the upper stratosphere. The development of designs for an operational electrical discharge altimeter and an ion tracer technique for the accurate measurement of linear air velocity is reported. The aerosol sampler and altimeter were tested during an experimental 127,000-ft. balloon flight. Both instruments performed all of their programmed functions as planned. (C.H.)

**27702** (PNE-239F) RELEASE AND MOVEMENT OF RADIONUCLIDES IN SOILS CONTAMINATED WITH FALLOUT MATERIALS FROM AN UNDERGROUND THERMONUCLEAR DETONATION. E. H. Essington, H. Nishita, and A. J. Steen (California. Univ., Los Angeles. School of Medicine. Lab. of Nuclear Medicine and Radiation Biology). [1963]. Contract AT-04-1-GEN-12. 27p. (UCLA-12-524)

Fallout material from an underground thermonuclear detonation was analyzed to determine the presence of several longer liver radionuclides. Fission products that were identified were: $^{95}Zr$-$^{95}Nb$, $^{103}Ru$, $^{106}Ru$-$^{106}Rh$, $^{131}I$, $^{137}Cs$-$^{137}Ba$, $^{140}Ba$-$^{140}La$, $^{141}Ce$, and $^{144}Ce$-$^{144}Pr$. Other identified radionuclides, which probably were produced by neutron activation, were: $^{46}Sc$, $^{54}Mn$, $^{88}Y$, $^{102}Rh$, $^{181}W$, $^{185}W$, and $^{188}W$-$^{188}Re$. Radiotungsten was estimated to contribute about 90 per cent of the total gamma activity present in the fallout material 167 days after detonation time. The release of the radionuclides from the fallout material was studied in $H_2O$, chelating agents, and HCl. In $H_2O$ suspensions of fallout material the amount of soluble radionuclides increased up to 7 days whereas in HCl, they decreased. This effect was attributed to the reduced solubility of radiotungsten in acid solutions. Chelating agents as compared to water, generally increased the amount of soluble radionuclides, but the effect was small. In soil column studies, distilled water or a solution of CaDTPA was used as a leaching agent. Ruthenium-103 and $^{131}I$ were found in the leachates from the water leached soils. In the leachates from the CaDTPA leached soils, $^{140}La$ and $^{141}Ce$ were found in addition to $^{103}Ru$ and $^{131}I$. Apparently the complexing action of DTPA increased the solubility of $^{140}La$ and $^{141}Ce$. The movement of radiotungsten in soil columns depended on the soil type. Its movement was greater in Yolo (pH 8.0) and Sorrento (pH 7.8) containing montmorillonite than in illitic Hanford soil. (auth)

**27703** (UWFL-90) GAMMA-EMITTING RADIONUCLIDES IN TUNA SAMPLES FROM THE TOKYO CENTRAL FISH MARKET, 1962. Allyn H. Seymour (Washington. Univ., Seattle. Lab. of Radiation Biology). Sept. 5, 1963. Contract AT(45-1)-1385. 24p.

Samples of tuna obtained from Tokyo between May and Nov. 1962 were analyzed for $\gamma$-emitting radionuclides. Data are presented on the content of naturally-occurring $^{40}K$, $^{54}Mn$, $^{60}Co$, $^{65}Zn$, $^{95}Zr$–$^{95}Nb$, $^{103}Ru$, and $^{137}Cs$, in all samples and $^{55}Fe$ in samples with the greatest $\gamma$ activity. Results indicate that fallout during the spring and summer of 1962 contributed very little radioactivity to the tuna of the Western Pacific. (C.H.)

**27704** (OTS-62-11066/5-6) POLISH MEDICAL JOURNAL. Translation of Polish Med. J., 1: Nos. 5-6, 613-932(1962). 326p.

A separate abstract was prepared for one article on $\beta$ radioactivity in foods. Other articles in this journal are on general biological or medical subjects. (C.H.)

*For abstract of individual paper see: 27705.*

**27705** (OTS-62-11066/5-6(p.751-9)) GROSS BETA RADIOACTIVITY IN SOME POLISH FOODS OF PLANT ORIGIN. Preliminary Report. Z. Piechucki and J. Rdzanek. Translated from Polish Med. J., 1: 751-9 (1962).

Also published in Acta Polon. Pharm., 19: No. 1, (1962).

Results are reported from measurements of $\beta$ activity in grain and cereals, fruits, and vegetables from the 1959 and 1960 harvest in Poland. Data are included on $\beta$ activity in some food products of plant origin made over a 3-year period. (C.H.)

**27706** EXPOSURE TO FALLOUT RADIATION. Brit. Med. J., 1: 454(Feb. 22, 1964).

Levels of fallout nuclides in the biosphere and in milk in the United Kingdom are discussed. Milk samples collected from a large number of depots in 1963 showed that the average $^{90}Sr$ level was about 26 pC/g Ca, or twice the corresponding figure for 1962 and about four times what it was in 1960–1. The ratio of $^{90}Sr/Ca$ in the average national diet is not very different from that in the milk, and milk levels can be taken as a guide to the general situation for $^{90}Sr$. Strontium-89 has a half life much shorter than that of $^{90}Sr$ and its significance, already minor in 1962, was small in 1963. Iodine-131 with an even shorter half life was not detected on any occasion in 1963. The country-wide average for $^{137}Cs$ in milk was also twice what it was in 1962. The dietary analyses were used to deduce the dose of radiation to bone in 1963 from all components of fallout. Dose to bone marrow was one-half the dose in bone, the most heavily irradiated tissue. The highest bone dose received by children of about one yr of age was on an average about 30 mr. This is one-sixth the limiting dose for the population as a whole. Predictions about tissue doses in 1964 are uncertain, mainly because it is not known how the weather will affect the pattern of fallout, but by the end of 1964 the deposition of $^{90}Sr$ and $^{137}Cs$ should be decreasing appreciably. Even though the levels of these two isotopes in milk in 1963 were double what they were in 1962 it is suggested that there is no general cause for alarm. The genetic dose from fallout from its beginning in 1954 to the end of 1963 is estimated as 8% of that received from natural background radiation. The genetically effective dose is the mean population dose averaged over a 30-yr period, and any addition due to an unexpected doubling in fallout in a single year, as in 1963, forms a very small proportion of the total. (BBB)

**27707** RADIOACTIVE SPECIES PRODUCED BY COSMIC RAYS IN THE BOGOU IRON METEORITE. J. P. Unik, D. J. Henderson, and J. R. Huizenga (Argonne National Lab., Ill.). Geochim. Cosmochim. Acta, 28: 593-4 (May 1964).

A 300-g slice of the Bogou iron meteorite, which fell on August 14, 1962, was quantitatively analyzed 239 days after fall for radioactive nuclei by nondestructive analysis of the emitted $\gamma$ rays. Three different methods were used to record and analyze the $\gamma$ spectrum. With the detection sensitivities of the method used, only $^{54}Mn$ was positively identified and measured. Upper limits were placed on the presence of several other activities in the meteorite. (P.C.H.)

**27708** CALCIUM ISOTOPE RATIOS IN THE HOMESTEAD AND PASAMONTE METEORITES AND A DEVONIAN LIMESTONE. Milo M. Backus, W. H. Pinson, L. F. Herzog, and P. M. Hurley (Massachusetts Inst. of Tech., Cambridge). Geochim. Cosmochim. Acta, 28: 735-42(May 1964).

Isotope abundance results obtained for common Ca (Devonian limestone) were determined and are given in atom per cent. Calcium extracted from the Homestead, Iowa, chondrite was isotopically identical to common Ca to within ±1%, except for a better measurement of $^{48}Ca/^{40}Ca$ ratio of $(33 \pm 1) \times 10^{-6}$. In contrast, $^{40}Ca$ may be depleted by as much as 3% in the Pasamonte achondrite, which reportedly has a Ca/K ratio of 150. (P.C.H.)

**27709** PHYSICAL ASPECT OF FALLOUT IN THE TROPOSPHERE. R. Koike (Japan Meteorological Agency, Tokyo). Geophys. Mag. (Tokyo), 31: 331-5(Nov. 1962).

Horizontal diffusivity of radioactive fallout in the troposphere is affected by the upper meteorological status, especially the pressure pattern. Radioactive substances released in the Arctic go around the earth in about 25 days. It is very important to examine the relation between the upper pressure waves and the amount of radioactivity on the ground. Higher values of radioactivity are measured on the west side of an upper trough when the waves advance to the east, and vice versa. (auth)

**27710** INFLUENCE OF THE ATOMIC EXPLOSIONS IN THE SAHARA DESERT. R. Koike (Japan Meteorological Agency, Tokyo). Geophys. Mag. (Tokyo), 31: 337-42(Nov. 1962).

Large amounts of radioactive particles were observed at many places in Japan on February 13, 1960, after the Sahara atomic bomb tests. The radioactive decay curve of samples at Tokyo is expressed by $N = N_0 t^{-1.8}$ (till t = 25 days) and $N = N_0 t^{-1.1}$ after t = 25 days), where N is the amount of radioactivity at the time after the nuclear fission and $N_0$ is that at t = unity. The radioactive substances were carried by the strong westerlies of upper air, and reached the ground at Tokyo on February 17, being captured by the raindrops associated with a cold front. (auth)

**27711** DATA OF VERTICAL DISTRIBUTION OF ATMOSPHERIC RADIOACTIVITY. Kishocho Kenkyu Jiho, 14: 852-62(Mar. 1963). (In Japanese)

Results are reported on the vertical distribution of $\gamma$ radioactivity in Japan from 1954 through 1962. Measurements were made with balloon-borne G-M counters surrounded by six anticoincidence counters. Additional measurements were made using aeroplane-borne counters. (C.H.)

**27712** PASSAGE OF A RADIOACTIVE CLOUD OVER NORWAY, NOVEMBER 1962. T. Hvinden, A. Lillegraven, and O. Lillesaeter (Norwegian Defence Research Establishment, Kjeller). Nature, 202: 950-2(June 6, 1964).

Fallout measurements made in Norway in Nov. 1962 indicated that radioactive materials from atmospheric nuclear tests may be deposited on the ground thousands of miles away in concentrations high enough to be of concern. Measurements of fallout activity in ground-level air indicated that a radioactive cloud passed over Norway in a northwesterly direction at a speed of about 500 km/24 hr between Nov. 6 and Nov. 15. There was little precipitation during the period and normal winds prevailed. On the basis of the $^{132}Te/^{140}La$ ratio in the fallout, the explosion date was set on Oct. 30 or Nov. 1. The U. S. Atomic Energy Commission reported one test explosion on Oct. 29 and two others on Nov. 3, all intermediate yield bursts at Novaya Zemlya. No other tests were reported during the period. Data are presented on the composition and activity

of the fallout with emphasis on $^{131}I$. The radiation dose to infants' thyroids from $^{131}I$ in milk during Nov. and Dec. was estimated to be about 40 mrad. It is pointed out that the grazing season for cows ends in Norway before Nov. 1, and that, if the radioactive cloud had passed during the grazing season, the $^{131}I$ content in milk would have exceeded 10 nC/l. (C.H.)

**27713** RADIOACTIVE OCEAN SUSPENSIONS. I. ISOTOPES OF THORIUM IN OCEAN SUSPENSIONS. Yu. V. Kuznetsov, V. K. Legin, A. P. Lisitsyn, and Z. H. Simonyak. Radiokhimiya, 6: 242-54(1964). (In Russian)

Samples of ocean suspensions were taken at numerous places in the Indian Ocean. The concentrations of ionium and thorium in the various types of suspensions were determined. The relationships between these elements and the principal other components as well as the granulometric size of the suspension particles were determined. Since the relationships of the two elements were found to be very different, it was concluded that ionium and thorium are in very different forms in the suspensions. A close relationship was established between the ionium content in the suspension and the total phosphorus, iron, organic, and calcium carbonate contents. No relationship was detectable between ionium and amorphous silicon or magnesium carbonate or between thorium and iron, organic, calcium carbonate, or amorphous silicon. The data obtained indicated the possibility of determining the rate of sedimentation from the Io/Th ratio. The ionium and thorium contents in the water of the Caspian and Baltic seas and in muds of the Indian Ocean are shown for comparison. (TTT)

**27714** HEALTH ASPECTS OF NUCLEAR WEAPONS TESTING. Gordon M. Dunning (Atomic Energy Commission, Washington, D. C.). [1967]. 60p. $0.25(GPO)

The radiation exposures of persons from radioactive fallout during 14 years of atmospheric nuclear weapons testing spread over an 18-year period are estimated. During this period about 340 nuclear detonations in the atmosphere, with a total energy release of about 511 million tons, were announced. Data from these tests are reviewed in an effort to postulate the risks associated with nuclear weapons testing. Topics discussed include the radiation dose of man from natural background radiation and medical sources; the sources and nature of fallout; whole-body and skin exposures to fallout; an evaluation of the radiation dose from $^{131}I$, $^{89}Sr$, $^{90}Sr$, and $^{137}Cs$ from fallout and $^{14}C$ produced naturally by the interaction of cosmic rays with N in the atmosphere; the contamination of air and water by fallout fission products; the effects of blast waves and thermal radiation from nuclear explosions; ground motions and structural responses to nuclear explosions; and effects of nuclear detonations on weather. Safety procedures at U. S. nuclear test sites are appended. (35 references.) (C.H.)

**27715** APPARATUS TO SIMULATE RADIOACTIVE FALLOUT. John F. Batter, Jr. (to Technical Operations Inc.). U. S. Patent 3,138,711. June 23, 1964. Filed Dec. 2, 1960.

An apparatus for simulating a radiation fallout field of any desired configuration, is designed which is operated remotely without danger to the operator. The apparatus comprises a portable radiation source, a continuous hollow conduit arranged over the field, means for continuously propelling the source through the conduit, and isotropic radiation dosimeters located at least at one point in the field, such as in a structure. (D.L.C.)

## Techniques and Equipment

**27716** STUDY OF FOSSIL FISSION TRACES IN MICA. M. Maurette, P. Pellas, and R. M. Walker (Faculte des Sciences, Orsay, France and Laboratoire de Mineralogie du Museum, Paris). Bull. Soc. Franc. Mineral. Crist., 87: 6-17(Jan.-Mar. 1964). (In French)

Cleaved mica samples were subjected to attack by hydrofluoric acid after neutron irradiation, rendering the tracks produced by uranium fission products observable by optical microscopy. The ages of the minerals were calculated from the ratio between the densities of old traces and new traces inducted by the neutron irradiation. Of eleven micas studied, only one gave an age verifying that obtained by classical dating. The other ten micas gave ages far too recent, the discrepancies increasing with the actual age. These divergences can be explained by enrichment in uranium of the micas after crystallization and thermal restoration of regions damaged by fission fragments. (D.C.W.)

**27717** THE USE OF A RADIOISOTOPE GAMMA-GAMMA PROBE FOR GEOLOGICAL EXPLORATION IN THE 39 STRATA OF ANNA VALLEY IN THE BREZOVYCH MOUNTAINS. L. Šimon, A. Přibyl, and R. Brož (Mining Inst., CSAV, Prague). Jaderna Energie, 10: 54-7(1964). (In Czech.)

A radioisotope, gamma-gamma probe was developed with an instantaneous cathode follower. The results of preliminary tests showed that the probe was a suitable well-logging device for making measurements directly in a bore hole. The instrument reliably detected the border between igneous rock and granular material. A $^{60}Co$ source and a G-M counter are shielded from each other with Pb and are incorporated into a metal tube. The $\gamma$ count rate picked up by the G-M tube is a function of the type of surrounding soil. The analysis can be performed directly in the bore hole. (TTT)

**27718** A NEW METHOD FOR DETERMINATION OF THE ABSOLUTE AGE OF STONES. Umschau Wiss. Tech., 64: 314-15(May 15, 1964). (In German)

Ages of uranium-containing stones were determined by comparing fossil track of uranium fission products through the material with fresh tracks for nuclear fission after irradiation of the sample in a reactor. Photographs of microscopic images were used for the comparisons. (M.C.G.)

## Thorium and Uranium Minerals

**27719** PRECISION INTERCOMPARISONS OF LEAD ISOTOPE RATIOS: IVIGTUT, GREENLAND. E. R. Kanasewich and W. F. Slawson (Univ. of British Columbia, Vancouver). Geochim. Cosmochim. Acta, 28: 541-9(May 1964).

Isotopic analyses were made on the NBS 200 galena and iodide from Ivigtut, Greenland. Five additional samples were analyzed also. All of these agree within $\frac{1}{4}\%$. The Pb isotope ratios obtained were $^{206}Pb/^{204}Pb = 14.70$, $^{207}Pb/^{204}Pb = 14.82$, and $^{208}Pb/^{204}Pb = 34.92$. An interpretation for the origin of the leads is suggested through the use of a simplified multi-stage model. The first event occurred at least $3 \times 10^9$ yr ago and the last event probably took place about $1.2 \times 10^{10}$ yr ago. Ivigtut leads are by this interpretation anomalous. A reasonable crustal Th/U ratio of 4.6 was obtained from the model. (P.C.H.)

**27720** THE RADIOACTIVITY OF THE MANSFIELD MARINE BAND, YORKSHIRE. D. A. Spears (Univ. of Sheffield, Eng.). Geochim. Cosmochim. Acta, 28: 673-81(May 1964).

Chemical and radiometric techniques were used to study the distribution of radioactivity in the Mansfield Marine Band. Thorium is thought to be associated with the clay minerals and possibly to have been fixed during the weathering of the source rocks. Some U is concentrated in phosphatic material, but most is associated with the clay minerals, and there is an absence of U-rich minerals. It is thought that factors controlling the sorption of U are the presence of reducing conditions, a slow rate of deposition, and the salinity. (auth)

**27721** URANIUM DECAY SERIES DISEQUILIBRIUM IN AGE DETERMINATION OF MARINE CALCIUM CARBONATES. Richard Lee Blanchard. Thesis. St. Louis, Washington Univ., 1963. 175p.

The extent of disequilibrium between certain members of the three naturally occurring radioactive heavy element families in modern and fossil marine calcium carbonates was investigated. The $^{230}Th/^{238}U$ and $^{226}Ra/^{238}U$ ratios of the latter were determined with a view of ascertaining the conditions under which these two ratios may serve as measures of geologic age. If meaningful ages are to be obtained by these methods three conditions must be fulfilled: The original specimen must contain a measurable quantity of uranium; it must be initially free of $^{230}Th$ and $^{226}Ra$, or must contain these nuclides in low and predictable concentrations; and the specimen must, during aging, behave as a closed system for $^{238}U$, $^{230}Th$, and $^{226}Ra$. The results obtained in the analysis of 30 modern marine mollusks and 32 fossil marine carbonates (mollusks and corals) are reported. Modern and fossil marine shells and corals contain uranium at low but measurable concentrations, usually 0.1 to 5 ppm. The average uranium concentration in fossile shells is higher than in modern shells collected from the same locality. The predominant thorium alpha activity in living marine shells is associated with $^{228}Th$, which arises from the decay of $^{228}Ra$ in the specimen. The $^{230}Th$ concentration in these shells is below the limit of detection, which in most instances can be taken to mean less than 5% of the amount of $^{230}Th$ required for secular equilibrium with the $^{238}U \cdot {}^{226}Ra$, on the other hand, is invariably present in living shells and usually at a concentration level well above that required for equilibrium with uranium. Whether or not a particular specimen fulfills the third condition listed above is difficult to determine. To minimize the possibility of using materials in which such changes have occurred, the following criteria are recommended for the selection of specimens to be analyzed: the specimen must be well preserved and must show no evidence of weathering or recrystallization; the $^{230}Th/^{238}U$ ratio must be constant with respect to position within the specimen. On this basis, the ideal specimen is a well preserved shell consisting of pure aragonite. Using the foregoing criteria as a guide 13 marine fossil shell samples and 7 fossil coral core samples were selected for analysis. The ages assigned to these selected samples on the basis of $^{230}Th/^{238}U$ ratios correspond rather well with age estimates based on stratographic considerations and/or radiocarbon analyses. (Dissertation Abstr., 24: No. 11, 1964)

# HEALTH AND SAFETY

*Refer also to abstracts 27706, 27712, and 27714.*

**27722** (AERE-HP/M-119) CALCULATIONS OF THE FILTRATION OF AIRBORNE DUST BY AN ASBESTOS-BEARING FILTER PAPER. R. F. Hounam (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). May 1957. 10p.

Filters made from asbestos-bearing paper on very fine glass fiber paper are now used at A.E.R.E. for high-efficiency air filtration. The formulas used in A.E.R.E. HP/M 43 to predict the performance of air cleaning and air sampling media are applied to calculate the performance of an asbestos-bearing paper. (auth)

**27723** (NP-13724) IRRADIATION DOSES RESULTING FROM A CRITICALITY ACCIDENT. W. Schueller (European Company for the Chemical Processing of Irradiated Fuels, Mol, Belgium). July 1963. 18p. (ETR-150)

Estimates were made of the neutron and $\gamma$ radiation doses that would result from a criticality accident in a fissile material solution. Irradiation doses from a criticality accident were determined for an unshielded system and behind a standard concrete shield of different thicknesses. It was determined that an average criticality accident in a solution system will yield about $10^{17}$ fissions, although the maximum credible burst may be as high as $3 \times 10^{18}$ fissions; $10^{17}$ fissions will cause a lethal dose of about 8000 rem adjacent to the unshielded reactor, or 0.3 rem behind 150 cm of concrete shield. The dose from the maximum credible accident are 30 times as large. A semi-lethal dose (400 rem) must be expected from an average accident if the shield is less than 40 cm, and from the maximum accident for shields below 85 cm. (C.H.)

**27724** THE FIRST AMENDMENT TO THE FIRST RADIATION PROTECTION REGULATION. J. Pfaffelhuber. Atomwirtschaft, 5: 230-2(May 1964). (In German)

The Erste Verordnung zur Aenderung und Ergaenzung der Ersten Strahlenschutzverordnung (first Regulation to change and supplement the First Radiation Protection Regulation) predominantly serves to bring certain stipulations into line with the changed Euratom standards for health safety. These stipulations concern the general amounts of radioactivity that can be handled without license and the concentration values for radioactive materials. This has been accomplished in the main by replacing Supplements I and II to the Erste Strahlenschutzverordnung by new Supplements. A license is accordingly no longer necessary in dealing with quantities of natural Th up to 100 g. Similarly, notification and prior licensing for $^{187}$Re, $^{87}$Rb and $^{147}$Sm are no longer required. In addition the maximum permissible concentrations of a few radionuclides in water or air have been changed. (auth)

**27725** PUBLIC HEALTH PLANNING FOR DISASTER. D. Kubryk (Dept. of National Health and Welfare, Ottawa). Can. J. Public Health, 54: 403-9(Sept. 1963).

Some of the more common emergency tasks that must be considered by local health departments in emergency public health planning for civil defense are enumerated. Indicated under the appropriate headings are some tasks common to both probable target areas and nontarget areas, and others are restricted to either target or nontarget areas (probable target areas are cities in Canada considered to be most likely targets for nuclear attack). Nontarget areas are divided into support areas and reception areas. Emergency planning is considered in terms of attack and post attack phases: attack (D = 0 to +7 days); immediate postattack (D = +8 to +30); recovery (D = +31 to +185); and rehabilitation (D = +186 to +365). Essential emergency public health activities are listed as follows: public health planning, operations and administration, radiation monitoring and decontamination, radiation safety advisory service, radiation health laboratory services, chemical warfare protective measures, water testing, purification and decontamination, water distribution systems, emergency sewage waste and refuse disposal methods, emergency field sanitation, sanitary control of emergency feeding services, insect and rodent control, communicable disease and biological warfare control, and public health laboratory service. An appendix is provided which further defines each of these activities. It is concluded that to achieve preparedness for emergency the health department must carry out the following measures: plan the program of the emergency public health service within the framework of the municipal emergency health services; organize to meet the health requirements of a municipal disaster plan; evaluate the needs and resources; recruit auxiliary personnel; augment basic supplies and equipment by stockpiling or increasing inventory or organizing mutual aid; train staff and auxiliary personnel; and educate the public and the personnel in order that with adequate planning and preparation they can survive. (BBB)

**27726** EMERGENCY PUBLIC HEALTH PLANNING IN BRITISH COLUMBIA. Anthony A. Larsen (Emergency Health Services, Victoria, Can.). Can. J. Public Health, 54: 410-16(Sept. 1963).

The health problems that will arise in the event of a major natural disaster or an enemy attack with nuclear weapons are described. These include the need for the provision of immediate medical care for overwhelming numbers of badly injured people, and the maintenance of health and the prevention of disease in the surviving uninjured population, many of whom will be evacuees living in overcrowded quarters on an inadequate diet and may have absorbed appreciable amounts of radiation. Problems that will face an emergency public health service after a major natural disaster or enemy nuclear attack will not remain static, but will alter with the passage of time. Four phases are discussed: attack period, postattack period, recovery period, and rehabilitation. Provincial public health responsibilities and planning which have been developed for British Columbia are described. Other functions to be provided by emergency health services are enumerated. (BBB)

**27727** NUCLEAR DISASTERS AND EMERGENCY WATER SUPPLY. W. D. Hurst (Chief Engineer, City of Winnipeg, Manitoba). Can. J. Public Health, 54: 417-25(Sept. 1963).

The following aspects of nuclear disaster problems are considered: effects of nuclear weapons; assessment of the vulnerability of a waterworks system; protective measures to be taken prior to attack against fallout, blast, and thermal effects; conditions to be expected following an attack; and measures to be taken to restore system operation, or, alternatively, if the postattack examination shows that the normal supply system is destroyed beyond repair, the provision of alternate facilities. (BBB)

**27728** FOOD FOR SURVIVAL. R. C. Morrow (Public Health Veterinarian, Winnipeg, Manitoba). Can. J. Public Health, 54: 426-30(Sept. 1963).

The selection of foods, to be consumed by survivors of a thermonuclear attack, is considered so that fallout-contaminated produce can be avoided. It is concluded, after reviewing the foods available in the Canadian countryside, that food for survivors following nuclear attack on target areas can be readily obtained sufficient for them to exist for quite a period of time without undergoing any undue hardship. (BBB)

**27729** SAFETY OF NUCLEAR PLANTS AND HEALTH PROTECTION OF WORKERS AND PEOPLE AGAINST HAZARDS ARISING FROM PEACEFUL USES OF NUCLEAR ENERGY. Giuseppe Belli. Comit. Nazl. Energia Nucl., Notiziario, 10: No. 5, 19-28(May 1964). (In Italian)

The law, approved by the Presidential Decree of February 1964, for safety in nuclear plants and health protection of workers and people against hazards arising from peaceful uses of nuclear energy is reviewed. (M.C.G.)

**27730** POSSIBILITIES OF A STUDY OF ACTIVE DEPOSITIONS BY THE IONOGRAPHIC METHOD. Louis Avan and Ginette Gaillard (Faculte des Sciences, Clermont, France). Compt. Rend., 258: 420-3(Apr. 20, 1964). (In French)

The use of alpha spectrometry by the ionographic method to follow the deposition of natural alpha emitters in specified atmospheres is discussed, using the results of studies on radium and thorium. The techniques, resolution, and optimum conditions are considered. (D.C.W.)

**27731** APPLICATION OF THE IONOGRAPHIC METHOD TO THE STUDY OF THE PRESENCE OF ALPHA EMITTERS IN NATURAL ATMOSPHERE. Louis Avan and Ginette Gaillard (Faculte des Sciences, Clermont-Ferrand, France). Compt. Rend., 258: 4245-8(Apr. 27, 1964). (In French)

Some possibilities of the photographic method in the determination of alpha emitters in various natural atmospheres and in the study of their evolution in time or space are illustrated. (tr-auth)

**27732** ON THE EFFECTS OF STRONTIUM-89 ON THE MICROFLORA IN BIOLOGICAL FILTERS. B. N. Il'in. Gigiena i Sanit., No. 2, 102-4(Feb. 1964). (In Russian)

Deactivation of waste water containing $5 \times 10^{-7}$ C/l of $^{89}Sr$ with the maximum content in the biological layer reaching $10^{-5}$ C/kg of raw weight, was analyzed. The chemical activity of heterotrophic microorganisms in the biological layer and the growth during the first 8 to 10 months were not affected by the $^{89}Sr$. Neither was the performance of a water purification biofilter influenced. Concentrations of $^{89}Sr$ from $5 \times 10^{-2}$ to $5 \times 10^{-6}$ C/l did not effect the bacteria in the biofilter microflora. (R.V.J.)

**27733** MODIFIED METHOD FOR DETERMINING THE ACTIVITY OF A $\beta$-CONTAMINATED SURFACE BY HUMID SMEARS. A. V. Terman and M. I. Enikeev (Central Medical Inst. for Graduate Work, Moscow). Gigiena i Sanit., No. 4, 69-71(Apr. 1964). (In Russian)

A method is suggested for using humid smears of $\beta$ contaminated surfaces taken under identical conditions and measured with an end-window counter. The method prevents any loss of radioactive material and yields results 5 to 10 min after the smears are taken. (R.V.J.)

**27734** THE RADIOLOGIST AND SOME ASPECTS OF THE RADIATION PROBLEM IN NUCLEAR WARFARE. J. Hazel (Royal Victoria Hospital, Montreal). J. Can. Assoc. Radiologists, 14: 182-6(Dec. 1963).

In a review of the radiation problems associated with nuclear warfare, the role of the radiologist is emphasized as, first, a physician, and secondly, in view of his special knowledge of the radiation aspects, an adviser to those in charge. A comparison of the ranges of blast, heat, and initial radiation effects for nuclear bombs of various sizes is tabulated. The acute radiation syndrome is described, and the concept of equivalent residual dose (ERD), developed by the National (Canadian) Committee on Radiation Protection and Measurements, to help predict the biological and medical consequences of exposure to radiation as a result of an accumulated dose is explained. Late effects of the radiation from a nuclear explosion, which are discussed, are the genetic effects due to external $\gamma$ radiation and internal radiation injury, and late somatic effects including, sterility, leukemia, aplastic anemia, cataract, cancer of skin, lung, bone, and shortening of life span. Various means for protection against radiation injury are considered. Decay of mixed fission products in fallout is outlined. Half-value layer thicknesses of common materials for initial and residual $\gamma$ radiation, for use in fallout shelter, are tabulated. Problems resulting from radioactive materials incorporated into plant and vegetable food chains are also considered. (BBB)

**27735** PROTECTION AGAINST THERMAL BURNS FROM NUCLEAR WEAPONS. J. Raymond Hinshaw. J. Oklahoma State Med. Assoc., 56: 212-15(May 1963).

The nature of thermal injury from nuclear detonations is described, and some experimental data on pigs and human volunteers are used to form the basis for recommendations for protection of human populations who may be exposed in a thermonuclear attack. (BBB)

**27736** PROTECTION AGAINST RADIATION AND CONTAMINATION. H. J. Dunster (United Kingdom Atomic Energy Authority, Harwell, Berks, Eng.). Lab. Pract., 12: 243-8(Mar. 1963).

A brief discussion of radiation hazards and permissible doses is followed by a discussion of methods of control. It is shown that control of external radiation is based on considerations of distance, time, and shielding, and control of contamination involves considering the chemical and physical form of the radioactive material and its overall activity. Emergency procedures are discussed briefly. It is concluded that radioactive materials are not significantly more toxic than conventional laboratory chemicals. (auth)

**27737** CIVIL DEFENSE IN THE UNITED KINGDOM. Daniel Thomson (Ministry of Health, London). N. Y. State J. Med., 63: 1841-3(June 15, 1963).

An account of Civil Defense in the United Kingdom, as it affects the medical profession, is given. The National Medical Manpower Committee, composed of eminent doctors, advises on the best methods of utilizing medical manpower, and makes allocations of physicians between the Armed Forces and the various civilian services. (BBB)

**27738** SECOND NATIONAL X-RAY STUDY. Donald R. Chadwick (Public Health Service, Washington, D. C.). New Engl. J. Med., 270: 586-7(Mar. 1964).

The U. S. Public Health Service plans to undertake the second of a series of national x-ray studies designed to provide additional information about the x-ray experience of the United States population. These studies are being conducted jointly by the Division of Radiological Health and the National Health Survey of the Public Health Service. The proposed study was planned with the advice of radiologists and physicists on the basis of a report on a field trial conducted in Berks County, Pennsylvania, during the summer of 1963 to determine the feasibility of the meth-

odology to be used in the national study. The national study will extend the information published in the earlier National Health Survey report by providing radiographic, fluoroscopic, and therapeutic exposure estimates for a representative sample of the United States population. A third study is planned in which these exposure data will be translated into dose estimates to specific body organs. The data-collection phase of the current study will begin in April, 1964, with a household interview survey in which information on x-ray visits will be obtained for the preceding 3-month period. The survey will cover ~10,000 households and 32,000 persons. From May through September, 1964, follow-up questionnaires and film packs, designed to provide the required exposure information, will be mailed to practitioners or facilities identified in the household-interview survey. It is estimated that ~6000 x-ray facilities will be involved. In each case, authorization to provide the requested information will have been obtained from the household respondent, and all information pertaining to individual patients, practitioners, and facilities will be treated confidentially; only statistical summaries will be made available for publication. (BBB)

**27739** NUTRITION IN FALLOUT SHELTERS. Nutr. Rev., 21: 298-300(Oct. 1963).

Results are reported from a fallout shelter habitability study. Emergency rations were fed to young males in good health for a 2-week period. The ration was based on a commercial survival cracker, containing about 30 calories each, supplemented by hot condensed soups, jams, peanut butter, sugar, and a cream substitute for use in instant coffee. The average water intake was 1,290 ml/day with additional 170 ml/day furnished in the rations. No clinically apparent deficiency states were observed in the men at any time. (C.H.)

**27740** THE SCOPE OF MEDICAL PROBLEMS IN NUCLEAR WARFARE. Neville Oswald (St. Bartholomew's Hospital, London). Practitioner, 187: 345-8(Sept. 1961).

Medical aspects of handling casualties that might be expected as a consequence of a thermonuclear attack upon Britain are discussed. The responsibilities of physicians and laymen in caring for casualties are outlined. (BBB)

**27741** THE CALCULATION OF TIME OF STAY OF PATIENTS IN ISOTOPE WARDS. H. Stegmann and Th. Schikora. Radiobiol. Radiotherap., 5: 185-99(1964). (In German)

In determining the time of rest after which a patient treated with radioactive isotopes is to be discharged from a nuclear medical ward, both the interests of radiation protection economic factors must be considered. The necessary time of rest depends on three different possibilities of the environmental danger. Legal regulations and corresponding criteria are proposed. Factors considered include environmental danger due to the radiation emitted by the patient, personal danger from excretions of the patient, and, contamination of the sewage system by the excretions of the patient. To guarantee complete radiation protection, a patient should be discharged only if all these three criteria are fulfilled. General equations for the activity in the patient, for the daily activity of excretions, and for the activity in the sewage on any day after application are given. For the isotopes $^{131}I$, $^{32}P$ and $^{198}Au$ these equations are specified using mean values for the particular excretor contents. The times of rest calculated according to the proposed method from equations for different applications are presented. (auth)

**27742** THE MANAGEMENT OF MASS CASUALTIES. Jorgen H. Berner, Jr. (Forsvarets Sanitet, Oslo). Tidsskr. Norske Laegeforen., 83: 932-5(June 1, 1963). (In Norwegian)

The possible consequences of a nuclear war and the enormous casualty problems are discussed. In preparing for such emergency a general plan is discussed which makes possible, from the point of view of total defense, an approach to the problems which could arise. There will be a severe disproportion between resources of personnel and material and the requirements for treatment of casualties. Resources must be increased as far as possible, a rigorous economy is necessary, and demands must be reduced. Cooperation between the civil and military health authorities must be further extended. The injured must be sorted according to a definite system and this sorting must aim at groups of injured with different priorities for further evacuation and treatment. An evacuation chain must be organized in which all the medical units both military and civil, together with civil hospitals, act as links in the chain. All treatment must be standardized, first aid at the place of injury as well as surgical treatment at larger treatment centers. Essential emergency equipment must be standardized and stored. Certain groups of personnel will have to be given tasks which they would never be given in peacetime and therefore require additional training in peace time. Special treatment teams should be established to be selected and trained during peace time. (BBB)

**27743** PROTECTION AGAINST RADIOACTIVE FALLOUT. Haakon Harbek. Tidsskr. Norske Laegeforen., 83: 953-60(June 1, 1963). (In Norwegian)

The widespread fallout from large nuclear weapons, which is in principle of the local type, demands the establishment of specific protective measures in areas where material damage has not occurred. After mentioning the geographic and radiologic characteristics of fallout, the type of information necessary to evaluate the hazard in each case is pointed out: prediction, warning, measurement, and nature of the radiologic injury. Shelter is the most important means of protection and it can be achieved to some degree in many existing buildings, although the greater intensities demand heavier shielding. The feasibility of evacuation is discussed, and measures for the decontamination of yards and streets are mentioned. The contamination of skin and personal clothing must then be controlled and cleaning be prescribed where necessary. Contamination of foodstuffs and water is discussed with regard to their packing and provenience, and their possible use without monitoring for a short period. Criteria are given, based on data accepted in peace-time for a radiological emergency. Radiological instruments of importance in fallout protection are survey meters, self-reading dosimeters, and contamination monitors. Desirable measuring ranges are indicated and the procedure of measuring food and water contamination is discussed. (BBB)

**27744** THEORETICAL POSSIBILITIES AND CONSEQUENCES IN MAJOR ACCIDENTS IN URANIUM-233 AND PLUTONIUM-239 FUEL-FABRICATION AND RADIOISOTOPE-PROCESSING FACILITIES. C. E. Guthrie and J. P. Nichols (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 135(June 1964).

**27745** THE SAFETY TESTING PROGRAM AT ORNL. Karl W. Haff (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 208-9(June 1964).

**27746** TECHNIQUES OF HANDLING HIGHLY ACTIVE BETA- AND GAMMA-EMITTING MATERIAL. Donald C. Stewart (Argonne National Lab., Ill.). Chap. 3, p.167-258 of "Technique of Inorganic Chemistry. Vol. III." New York, Interscience Publishers, 1963.

Techniques for handling highly active $\beta$- and $\gamma$-emitting material, including laboratory design, shielded facilities, equipment for chemical operations, radiation effects, decontamination, and waste disposal are discussed. Data on shielding materials are tabulated. 245 references are included. (P.C.H.)

**27747** GLOVE BOX TECHNIQUES. Charles J. Barton (Oak Ridge National Lab., Tenn.). Chap. 4, p.259-333 of "Technique of Inorganic Chemistry. Vol. III." New York, Interscience Publishers, 1963.

Glove box techniques, including auxiliary equipment for handling toxic materials, laboratory design, experimentation with toxic materials, and controlled atmosphere enclosures for nontoxic materials, are discussed. 218 references are included. (P.C.H.)

**27748** TRANSPORT REGULATIONS: THE NEED FOR COMPATIBILITY. I. G. K. Williams (United Kingdom Atomic Energy Authority, London). 8p. (CONF-539-1)

From Canadian Nuclear Association Conference on Canada's Role in a World of Expanding Nuclear Industry, Toronto, May 1964.

The development of international regulations governing the transport of radioactive materials is reviewed. (C.H.)

# INSTRUMENTATION

## General

*Refer also to abstracts 27701 and 27846.*

**27749** (BNL-851) UNIVERSAL SPECTROMETER I. Andrew Kevey (Brookhaven National Lab., Upton, N. Y.). Mar. 1964. Contract AT-30-2-GEN-16. 11p.

The Universal Spectrometer is a general purpose machine to be used for neutron diffraction experiments. Its versatility allows single-crystal, powder, or polarized beam studies, and it can be converted into a 3-crystal machine for inelastic scattering. This report describes both the operational and the design aspects of the instrument. Specifications are given for the monochromator, shield, angle divider, gunmount pedestal, diffractometer, and counter and shield. (auth)

**27750** (HW-79280(p.7.1-22)) INSTRUMENTATION AND NONDESTRUCTIVE TESTING. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

PRTR Automatic Controller. The analog computer simulated system indicated a resistance toward instability for the reactor system. Neutron Flux Monitor. Uranium and plutonium detector samples are being irradiated to develop optimum regenerating neutron flux detectors. Rapid decrease of resistance with increasing temperature limits maximum operating temperature to 700°C for present boron-11 detector units. Microwave attenuation proportional to the ionization of a plasma gas is to be used as a flux monitoring method. Nondestructive Testing Research and Development. Eddy current test methods used for tubing for N-Reactor are illustrated. Improvements were made in the high stability laboratory prototype eddy current Zircaloy-2 hydride detectors. The degree of phase shift experienced by an ultrasonic beam reflecting from a solid surface is being investigated. USAEC/AECL Cooperative Program on Nondestructive Testing of Fuel Sheath Tubing. Development of a complete prototype inspection station using ultrasonic techniques for inspecting tubing with wall thickness of 0.017 in. was completed. (auth)

**27751** (HW-80284(p.7.1-18)) INSTRUMENTATION AND NONDESTRUCTIVE TESTING. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

PRTR instrumentation for automatic control, vibration analysis for process tubes, and gamma scanning are described. A regenerating (plutonium-containing) neutron flux detector, boron-11 detector, and microwave detector for in-pile flux monitoring are described. Applications of eddy-current, heat-transfer, and ultrasonic testing techniques are discussed. The USAEC-AECL program on nondestructive testing of fuel sheath tubing was continued; a standard was fabricated. (R.E.U.)

**27752** (ORNL-3578) INSTRUMENTATION AND CONTROLS DIVISION. Annual Progress Report for Period Ending September 1, 1963. (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 149p.

The development of basic instrumentation and instrumentation for radiation detection and monitoring, data handling and computation, process control systems, reactors and reactor control systems, and high-voltage accelerators is reported. The material is presented in eleven sections, ten of which have been abstracted separately. The remaining section deals with personnel and financial matters. (T.F.H.)

*For abstracts of individual sections see: 27753, 27754, 27755, 27788, 27789, 27790, 27846, 28187, 28937, and 29122.*

**27753** (ORNL-3578(p.6-36)) ELECTRONIC SYSTEMS AND COMPONENTS. (Oak Ridge National Lab., Tenn.).

Nanosecond electronic techniques offer the possibility of accumulating selected data in the presence of intense backgrounds of uninteresting and deleterious events. Modular circuits employing tunnel diodes for discrimination, coincidence, and anticoincidence functions are described. These circuits, along with transistor modules, have been used in experiments for high-energy recoil proton telescopes, time-of-flight instrumentation, and gamma-ray anticoincidence and pair spectrometers. Performance results of these circuits to variations in operating temperature and input-signal magnitude are given. Nanosecond circuitry was designed to exploit the difference in flight time of neutrons and gamma rays emitted from a target bombarded with a pulsed beam of monoenergetic protons. The circuitry allows a multicrystal gamma-ray spectrometer to be used concurrently as a pair spectrometer for energies from 1.5 to 10 Mev, and as a total absorption spectrometer for energies from 200 kev to 2.5 Mev. An instrument was designed to detect the passage of two or more protons through a plastic scintillator within a period of 0 to 25 nsec. If more than one proton traverses the scintillator during this period, an inhibit pulse is generated that is used in the logic network of the associated experiment. The addition of a zero set and a hysteresis set to the Snip-Snap single-channel analyzer resulted in larger input dynamic range of operation. An instrument is described for time-of-flight applications that is capable of distinguishing primary events sufficiently isolated in time from other possible primary events. Different energy secondaries of different time origins giving rise to identical times of flight are thus avoided. This system responds to pulses within 10 nsec of each other and rejects any events in which two primary events are spaced by less than the preset isolation interval (115 nsec). A time-to-pulse-height converter was designed to measure time signals as short as 0 to 50 nsec in a neutron time-of-flight spectrometer. A transistorized time-to-pulse-height converter was designed to cover the ranges of 4, 8, and 80 μsec. Pulses from avalanche transistors were provided from the input start and stop pulses to operate a digital time-interval meter for calibration checking. A circuit was designed that corrects for amplitude-dependent "walk" in the output of a time-to-pulse-height converter in the nanosecond range. This pulser provides two simultaneous 8-v negative pulses, each 4 nsec wide with a rise time and fall time of 0.7 nsec into 50-ohm lines, and three simultaneous 8-v pulses (two negative and one positive) that are delayed with respect to the first pulses. The delay is continuously variable over a range of 100 nsec. Specifications for a digital-type time-interval meter having a resolution of 2 nsec were written, and development by contract with an instrument manufacturer was completed. The system in use fission-fragment energy-correlation measurements is a three-parameter punch-tape storage system having a fast coincidence resolving time (40 nsec) and a circuit to reduce distortion

from pileup. A spectrometer was designed to give a time resolution of about 2 nsec and an efficiency of approximately 20% for a neutron energy of 350 kev. The resolution was measured using a $^{22}Na$ source. With a start-level range corresponding to 6 to 60 kev electron energy, the time resolution is approximately 1.6 nsec fwhm. A series of modules was developed to monitor the outputs of various instruments. These modules perform logic functions to determine the status of certain combinations of signals and to indicate, both locally and at a remote central point, the condition of any number of widely scattered instruments or combination of instruments. The modules are actuated by signals with two discrete states. All module dimensions are in accordance with CERN standards, which are being considered for adoption by ORNL. A solid-state linear count-rate meter was designed with full-scale readings from 10 to $10^5$ counts/sec in five ranges. The discriminator operates on signals from 0 to 10 v, and its paired-pulse resolution is 200 nsec. A parallel remote-control console containing duplicates of all control functions was fabricated to facilitate linear proton accelerator operation. (auth)

**27754** (ORNL-3578(p.67-77)) PROCESS INSTRUMENTATION AND CONTROL SYSTEMS ENGINEERING. (Oak Ridge National Lab., Tenn.).

An instrument control console for the ETR was designed, fabricated, and subjected to extensive analog simulation tests. A process instrumentation and control system for an oxygen separation plant was designed to provide a very high degree of reliability. Equipment was provided to measure and control the temperature of specimens of structural materials during irradiation in the ORR. The design of the instrumentation and control system for the Nuclear Safety Pilot Plant is 50% complete, procurement of instruments and equipment is 80% complete, and installation is 20% complete. Progress in instrumentation of the HRLEL is reported. An emergency panel was provided to monitor variables associated with the containment of processing facilities and to isolate the processing cells automatically in the event of an accident. A system of work scheduling, based on a modification of the critical path method, was adopted and is now fully operational. (auth)

**27755** (ORNL-3578(p.78-95)) PROCESS INSTRUMENTATION DEVELOPMENT. (Oak Ridge National Lab., Tenn.).

Tank-level telemetering from 24 intermediate level waste tanks to Building 3105 for the Operations Division was updated to provide greater accuracy with less maintenance and to utilize a minimum of leased telephone lines for the system. Instrumentation was developed to permit continuous monitoring of the $Cr^{6+}$ concentration in a Darex dissolver effluent stream. Both ultraviolet absorption and oxidation potential techniques were investigated; the oxidation potential method appeared more promising, and subsequent development work was concentrated on this technique. Investigations were continued in dynamic gas thermometry, utilizing sonic flow nozzles as high-temperature measuring devices. Stability tests of nozzle flow coefficients produced new information and also confirmed and clarified some previously reported data. Nozzle-mounting techniques were studied. A proportional power-control unit with silicon controlled rectifiers was designed and built. Test equipment was developed to determine the operating condition of three types of electronic process controllers. Three testers were built and operating procedures were written for their operation. A substantial saving in time has been realized over previous methods of controller testing which consisted of mocking up the process conditions at the repair facility. A low-velocity-air calibration facility was designed and built for the precise calibration of air velocity instruments and all types of hot-wire and rotating-cup anemometers. A primary-reference voltage standard, a series of freezing-point temperature standards, and a universal ratio set for d-c resistance measurements were placed in service. Foxboro M63 alarm switches were tested to determine the effects of various modes of a-c interference, and a modification that solved a false-signal problem was recommended and installed. A probe for helium leak detection in hot systems was designed. The probe is essentially a differential-screw-operated needle valve and differs from commercially available probes in that it has been made relatively insensitive to temperature changes. A sensitivity photometer was developed for evaluating commercially available watch and instrument dials containing tritium and other low-energy radioactive materials. The instrument measures the intensity of the emitted light from the dial to levels as low as $5 \times 10^{-7}$ lumen. A Bausch & Lomb microdosimeter reader was modified to provide better long-term stability with increased reading accuracy. A method for reading chemical dosimeters by measurement of transmitted monochromatic light was demonstrated, and instrumentation for rapidly checking ORNL dosimeter ampoules was developed. An instrument was developed to measure and record weight changes as small as 10 mg in chemical samples weighing up to 8 g. (auth)

**27756** (ORNL-TM-864) CALIBRATION OF THE ORNL MODEL Q-2240, CONTINUOUS AIR MONITOR. E. D. Gupton, W. F. Ohnesorge, and H. M. Butler (Oak Ridge National Lab., Tenn.). May 14, 1964. Contract W-7405-eng-26. 14p.

A method is presented for calculating approximately the response of the ORNL Model Q-2240, Beta Gamma Continuous Air Monitor to particulate-associated beta-gamma emitting isotopes, which may be collected by the monitor. Calculated values are shown for some common isotopes. (auth)

**27757** (ORNL-TM-885) METHODS OF ANALYSIS OF ELECTRICAL PERFORMANCE OF LONG CYLINDRICAL THERMIONIC DIODES. J. V. Wilson (Oak Ridge National Lab., Tenn.). May 13, 1964. Contract W-7405-eng-26. 24p.

The methods used to analyze the electrical performance of long cylindrical thermionic diodes are described. The equivalent circuit, differential equations, and corresponding difference equations are given. Computer programs for parameter studies of electrical performance for cases of both uniform and nonuniform input power (or temperature) are described. (auth)

**27758** (PWAC-423) DEVELOPMENT OF LIQUID METAL LEVEL PROBES. Salvatore J. Fanciullo (Pratt and Whitney Aircraft Div., United Aircraft Corp. Connecticut Aircraft Nuclear Engine Lab., Middletown). Apr. 27, 1964. Contract AT(30-1)-2789. 63p.

Evaluations of several liquid metal level-measuring devices led to the selection of a resistance-type probe for both continuous and discrete level measurements. This device is fabricated from a section of two to four conductor, metal-clad, ceramic-insulated, swaged material. The continuous level probe is bent into a "J" configuration, welded into the liquid metal containment vessel, and cap-welded at one end. Tests on various configurations of this device have led to the development of a J-probe which has less than 0.5 percent shift in calibration for a 1200°F change in temperature, and less than a 1.0 percent shift in calibration after 500 hours at 1000°F. Tests have indicated

that after a short time at temperature complete wetting occurs and, with proper surface preparation, errors due to this effect can be reduced to less than two percent after two minutes. These probes have been successfully applied to many test rigs. For discrete (one point) level determination, a straight probe has been designed. This I-probe is capable of giving a very accurate and reliable indication of liquid level at one point. (auth)

**27759** (RT/ING(64)-1) DESCRIZIONE DI UN'APPARECCHIATURA PER PROVE DI IRRAGGIAMENTO n-γ SU TERMOCOPPIE. (Description of an Apparatus for Testing of n-γ Irradiated Thermocouples). G. Bianchi and L. Matteuzzi (Italy. Comitato Nazionale per l'Energia Nucleare, Rome). Jan. 1964. 29p.

The behavior of in-pile thermocouples is described together with the causes which modify the mv-temperature characteristic under the n-γ irradiation effect. An experimental apparatus is described for calibrating in-pile thermocouples by means of four fixed points, that is, the freezing points of four pure metals: Sn, Pb, Zn, Al. This apparatus allows the thermocouple positioning from outside in correspondence with the four metals contained in graphite crucibles. Three types of thermocouples have been tested, namely Fe-Cost, Cr-Al, Cr-Cost thermocouples. The first experimental results are given. (auth)

**27760** (SCL-DR-64-54) DEVELOPMENT OF A DC GAGE HEAD. C. M. Furnberg (Sandia Corp. Livermore Lab., Livermore, Calif.). June 1964. Contract AT(29-1)-789. 20p.

The history and design characteristics of a d-c gage head (displacement transducer) developed at Sandia Corporation, Livermore Laboratory, for use in electronic gaging systems are given. Improved electrical and mechanical properties were obtained for the LVDT-type unit. (R.E.U.)

**27761** (TID-20670) TECHNIQUES FOR IN-PILE MEASUREMENTS OF FISSION GAS RELEASE. R. M. Carroll and P. E. Reagan (Oak Ridge National Lab., Tenn.). [1964]. Contract W-7405-eng-26. 26p.

The continuous release of fission gas from ceramic fuels is measured during irradiation in the Oak Ridge Research Reactor. The fuel specimens are heated by their own fission power, which is controlled by moving the specimen holder into or out of the neutron flux. Fuel specimens with thin cross-sections are used, both to prevent thermal stress rupture and to allow accurate temperature measurement. A continuously flowing sweep gas carries the fission gas outside the reactor where the radioactive isotopes are measured with a gamma spectrometer. The specimen temperature is controlled by air-cooling the specimen holder. The experiment is instrumented to function continuously and unattended. (auth)

**27762** (TIM-758) INVESTIGATION OF SPEED TRANSDUCERS FOR REACTOR USAGE. S. Fanciullo (Pratt and Whitney Aircraft Div., United Aircraft Corp. Connecticut Aircraft Nuclear Engine Lab., Middletown). Jan. 16, 1964. Contract AT(30-1)-2787. 4p.

Twelve Electro-Products Company, speed transducers Model #72.1275, were evaluated to determine the effects of gamma irradiation on magnetic pickup. This transducer incorporates ceramic insulated wire, an L-3A Steatite ceramic spool material and #31 Sauereisen potting compound. The body of the unit is type 416 stainless steel. The maximum operating temperature of this model is 800°F. The 72.1275 transducer is practically identical with the 79.927 unit which was previously tested except for slight difference in the body design. The transducer was recommended for use on LCRE. (auth)

**27763** (TRG-Report-748) WEAKENED-SECTION THERMOCOUPLE FOR USE ON REACTOR FUEL ELEMENTS AND CHANNEL COMPONENTS. D. H. Cooper and P. P. Guneratne (United Kingdom Atomic Energy Authority. Reactor Group, Windscale, Cumb., England). Feb. 25, 1964. 11p.

The technique of locally swaging a thermocouple cable, with the object of breaking the cable at this point and withdrawing it from the reactor before the cartridge is discharged, is described. Supporting tests and results of examinations to confirm that breaking loads are reproducible and that the performance of the cable is in no way impaired are detailed and reported. (auth)

**27764** (UCRL-13093) A TUNNEL DIODE RECYCLING TIME MARK GENERATOR. Final Technical Report. Harlan W. Lefevre (Oregon. Univ., Eugene). Feb. 1964. For Univ. of California Lawrence Radiation Lab., Berkeley. Contract W-7405-eng-48. 17p.

A recycling time mark generator was developed in which the only active element is a shunt-connected tunnel diode. The diode is mounted at the junction of a 50 ohm stripline T. Two legs of the T are joined with a length of coaxial cable; the third leg proceeds 2.5 cm to a five port mismatch. The mismatch provides five input-output ports, and its distance from the diode determines the pulse width. Pulse width is about 0.8 ns, and recycling periods as short as 3 ns and as long as 160 ns have been used. With a selected diode, up to 200 pulses can be simultaneously recirculated in a 160 ns RG-8 transmission line indefinitely. Short term instability of circulation period as measured by beating the radiated signal with a quartz crystal is <0.05 ps. Bias coefficient of circulation period is 8 ps per mv at 90 mv with a General Electric TD-103 diode, and the tuning range which can be obtained by varying bias is 150 ps. The temperature coefficient of circulation period is 1.5 ps per °C. These measurements were made with a circulation period of 100 ns. (auth)

**27765** ON LATTICE CONSTANT DETERMINATION WITH AUTOMATICALLY REGISTERING X-RAY GONIOMETERS. Horst Ebel (Technische Hochschule, Vienna). Acta Phys. Austriaca, 17: 389-91(1964). (In German)

The automatic registering of x-ray interference for lattice constant determination by a goniometer is discussed. Possibilities of eliminating sources of register errors are listed. Results are shown for a gold sample. (M.C.G.)

**27766** MONOCHANNEL AMPLITUDE ANALYZER, TRANSISTORIZED. A. Rincón (Junta de Energia Nuclear, Madrid). Anales Real Soc. Espan. Fis. Quim. (Madrid), Ser. A, 59: 187-98(Sept.-Oct. 1963). (In Spanish)

A transistorized one-channel pulse amplitude for γ nuclear spectrometry measurements is described. Exploration of the spectrum can be done manually or automatically by means of a suitable external linear voltage sweep. Analyzer output is then applied to a count rate meter and spectrum contour is given as a function of the count rate meter time constant and the slope of the voltage sweep. Circuit simplicity and low maintenance appeared to be major features of the design. Results for $^{60}Co$ with scintillation detectors are given. (auth)

**27767** A NEW COINCIDENCE-ANTICOINCIDENCE CIRCUIT SELECTOR. W. Warzanskyj and A. Tanarro (Junta de Energia Nuclear, Madrid). Anales Real Soc. Espan. Fis. Quim. (Madrid), Ser. A, 59: 213-26(Sept.-Oct. 1963). (In Spanish)

Transistorized three channel coincidence-anticoincidence equipment is described. Coincidence resolving time can be

adjusted between 0.1 and 2 us; delay time in each channel between 0.4 and 1.6 us; and paralysis time between 3.2 and 50 us. These values are stable. No delay-lines are used. (auth)

**27768** STUDY OF A 3160 Mc SUPERCONDUCTING CAVITY USED IN THE DEVELOPMENT OF A STABILIZED FREQUENCY OSCILLATOR. Nguyen Tuong Viet (Faculte des Sciences, Orsay, France). Compt. Rend., 258: 4218-21(Apr. 27, 1964). (In French)

An oscillator (described) with a frequency stability of $5 \times 10^{-9}$/min and $5 \times 10^{-8}$/hr at 4.2°K was realized, using a cylindrical lead cavity oscillating in the $TE_{111}$ mode. The stabilities at 293 and 77.3°K were 3 and $1.5 \times 10^{-6}$/min, respectively. At 293, 77.3, and 4.2°K, the resonance frequencies of the cavity were 3137.73, 3156.17, and 3160.28 Mc, respectively. (D.C.W.)

**27769** A PULSE MODULATOR THAT CAN BE USED AS AN AMPLIFIER, A MULTIPLIER, OR A DIVIDER. Jerome A. Rosenthal (Univ. of California, Berkeley). IEEE (Inst. Elec. Electron. Engrs.), Trans. Instr. Meas., IM-12: No. 3, 125-34(Dec. 1963). (UCRL-10754(Rev.))

A pulse modulator that can be used as an amplifier, a multiplier, or a divider is described. Some of its desirable features are that it can respond without delay to a change in input signal, is of very simple construction, and can be used to control either proportional or on-off systems. (auth)

**27770** NEUTRON SCATTERING: A TECHNIQUE FOR THE DIRECT DETERMINATION OF THE AMOUNT OF BIOLOGICAL FILM IN A PERCOLATING FILTER. B. R. Harvey (Water and Pollution Research Lab., Stevenage, Eng.), G. E. Eden, and N. T. Mitchell. Inst. Sewage Purif., J. Proc., 495-506(1963).

The efficiency and operating characteristics of trickling filters often must be determined before the thicknesses of biological films that develop on the filter media can be measured. Previous methods for film-thickness measurements have involved removal of filter media, washing off the biological films, and weighing them. Also, packed media used in filters have been removed and the film thickness measured. These methods have given valuable results, but they have limited application because of the effects of filter flow patterns and other operating parameters. A procedure was developed for film-thickness measurement based on the scattering of neutrons. This procedure seemed to yield successful results, and further tests are being conducted. (Public Health Eng. Abstr., Vol. 44, No. 5, May 1964)

**27771** TIME AND PULSE PARAMETERS OF THE "JALOUSIE" (SHUTTER) TYPE PHOTOELECTRONIC MULTIPLIERS. G. S. Vil'dgrube, Zh. M. Ronkin, and Yu. A. Kolosov. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 377-83(Feb. 1964). (In Russian)

The shutter-type photoelectric multipliers are widely used for the investigation of light phenomena of short duration. In view of the contradictory results obtained by various researchers concerning the time resolution characteristics of these instruments manufactured in the USSR, various properties, such as pulse duration, time-of-flight discrimination, and secondary effects of the shutter-type multipliers, were closely examined, checking in particular the dependence of those properties of the method of supply. Velocity oscillography and measurement of the pulse growth in fast coincidences were used in the study. The characteristic frequency and the amplitude of relaxation oscillations, which accompany the basic pulse, were measured; these phenomena cause the shock-type excitation of the output circuit of these instruments. The tests revealed that the sharpness of the pulse growth of the instruments No FEU-11B, 14, 15, and 16 meet the criteria set for the best foreign and Soviet instruments. Work is in progress to improve the time resolution of the instruments. (TTT)

**27772** THE FEU-56-TYPE PHOTOELECTRONIC MULTIPLIER. G. S. Vil'dgrube, N. V. Dunaevskaya, and D. B. Fedorova. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 384-7(Feb. 1964). (In Russian)

The 80-mm diameter and 125-mm long instrument, designated as FEU-56 (FEU = photoelectric multiplier), possessing a front window, was subjected to a detailed investigation. This shutter-type instrument is similar to the FEU-52 type device but is provided with a Sb–Cs photocathode placed on a transparent conducting support. The pulse resolution of the instrument was measured by means of a NaI crystal by comparison with the $^{137}Cs$ lines. The characteristic resolution did not exceed 5.5% while the energy equivalent of the noise at the 50 counts/sec level at an ambient temperature of 20 ± 5° amounted in average to 5 to 6 kev. The resistance of the insulation between two electrodes was not less than $10^9$ ohm. The measurements also indicated that the output pulse does not exceed (45 to 50) $\times 10^{-9}$ sec at a level of 0.1 of the maximum amplitude. Within the 0.1 to 0.9 amplitude limits the pulse growth is equal to (7 to 8) $\times 10^{-9}$ sec at the highest permissible supply rate. The temperature stability studies, carried out within the range from −60 to +120°C, revealed that within those limits the Sb–K–Na–Cs photocathode is the most stable one. The photomultiplier operated satisfactorily even when the γ-background was high and the system was kept under a large mechanical load. (TTT)

**27773** THICKNESS MEASUREMENTS OF THIN GOLD FILMS BY γ-RAY SPECTROSCOPY. Akira Tasaki, Motohiko Saitoh, and Akira Kinbara (Tokyo Univ.). Japan J. Appl. Phys., 3: 234-5(Apr. 1964).

The thickness of uniform Au films deposited on quartz plates by evaporation in vacuum were determined by neutron activation techniques, as well as by multiple beam interferometry. The errors for the former method were within 8%, while the error in the interferometric method increased from 5 to 80% with decreasing thickness. The activation technique is especially useful for thicknesses <100 Å and involves no self-absorption considerations. (D.C.W.)

**27774** SOIL MOISTURE INTERFACE EFFECTS UPON READINGS OF NEUTRON MOISTURE PROBES. G. Paul Lawless, Norman A. MacGillivray, and Paul R. Nixon (U. S. Dept. of Agriculture, Lompoc, Calif.). Soil Sci. Soc. Am. Proc., 27: 502-7(Sept.-Oct. 1963).

Measurements of soil moisture by the neutron scattering method are inaccurate when made in the presence of abrupt moisture changes. The effects of air-soil interfaces and of wet-dry soil interfaces were investigated using neutron probes of four different designs. Three of the probes were used to study the effects of wet soil layers within dry soil masses. Readings taken at shallow depths were found to have the greatest errors. These errors were always negative. Absolute error and depth within the soil to which this effect occurs were related to soil moisture content. Some means of correcting such errors should be used. Errors in determining moisture content of soil zones containing wet-dry interfaces or wet layers were not as serious, and could be neglected in many practical applications. This was especially true when depth reading increments of 6 in. or less were used. These errors were

usually negative. Neutron probes tend to underestimate soil moisture content at interfaces or in stratified profiles. Probe depth reading increments of 1, 3, and 6 in. all gave about the same accuracy of moisture determination. Twelve-inch reading increments gave errors of as much as 6 times greater than those of the smaller increments. The influence of probe geometry upon neutron meter readings is also discussed. When compared on a basis of equivalent source strength, in uniform soils, the probe with end placement of the source was found to be considerably more efficient than the probes with center placement of the source. (auth)

**27775** INCREASING THERMOCOUPLE RELIABILITY FOR IN-PILE EXPERIMENTS. Everett Babbe (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 55(June 1964).

**27776** A MINIATURIZED PRESSURE SENSOR FOR REACTOR ENVIRONMENT. Jackson Kinzer (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 55-6(June 1964).

**27777** ON A DOUBLE-FOCUSING MASS SPECTROMETER WITH COUNTER-INDICATOR AS HIGH-SENSITIVITY LEAK DETECTOR. F. Kirchner and A. Benninghoven (Universität, Cologne). Vakuum Tech., 12: 207-9(Nov. 1963). (In German)

A mass spectrometer leak detector is described, which has a higher detection sensitivity for small test gas amounts and a shorter call time for the ion measurement apparatus than other apparatuses. The method of operation and results of using this leak detector are discussed. (M.C.G.)

**27778** A FAST IONIZATION GAGE WITH HOT CATHODE FOR DENSITY MEASUREMENTS OF NEUTRAL GASES IN THE REGION OF A PLASMA AND A STRONG MAGNETIC FIELD. J. G. Bannenberg and F. G. Insinger (F.O.M.-Laboratorium voor Massascheiding, Amsterdam). Vakuum Tech., 12: 210-12(Nov. 1963). (In German)

A commercial ionization gage was changed so that a fast density measurement is possible in a 8000 G field in the presence of a plasma. The calculated time constant of 160 μsec for hydrogen was confirmed by direct measurement. The influence of the plasma and the radiation was greatly suppressed by screening. Measurements on a rotating plasma device (IXION) demonstrated the use of the gage. (auth)

**27779** NUCLEAR RADIATION EFFECTS ON ELECTRONICS ANALYSIS AND SYNTHESIS. J. E. Bell (Hughes Aircraft Co., Fullerton, Calif.). 6p. (CONF-536-1)

From National Winter Convention on Military Electronics, Los Angeles, Feb. 1964.

The effects of transient nuclear radiation on electronic circuits and systems, particularly the effects of nuclear explosions on missile systems, are discussed; and the basic interaction, component, circuit, and subsystem approaches to computer prediction of radiation effects are considered. Procedures for the design of radiation-hardened systems are discussed; examples of radiation-hardened circuits are included. Charge redistribution is considered in detail. (D.C.W.)

**27780** THE DESIGN OF RADIATION RESISTANT SEMICONDUCTOR CIRCUITS. DeWitt Landis. 33p. (CONF-541-1)

From International Solid State Circuits Conference, Philadelphia, Feb. 1964.

The effects of radiation on semiconductor devices are briefly reviewed, and a systematic approach to the design of semiconductor circuits for use in radiation environments is presented. Examples of circuits designed for such applications are shown. (D.C.W.)

**27781** INTEGRATED VACUUM CIRCUITS FOR ENVIRONMENTS OF INTENSE RADIATION. E. H. Boden. 8p. (CONF-536-3)

From National Winter Convention on Military Electronics, Los Angeles, Feb. 1964.

The construction of circuitrons (integrated circuits in which the passive elements are enclosed within the evacuated envelope of an electron tube) is described using a flip-flop counter circuitron as an example, and some tests on circuitrons under radiation and other conditions are summarized. The circuitrons operated reliably in environments of pulsed and steady-state radiation, shock, vibration, acoustic noise, and over a wide temperature range. (D.C.W.)

**27782** A TRANSISTORIZED, FREQUENCY MODULATED PROTON MAGNETIC RESONANCE SYSTEM FOR THE MEASUREMENT AND CONTROL OF MAGNETIC FIELDS. W. C. Olsen (Univ. of Alberta, Can.). 47p. (CONF-63-8)

From American Physical Society, 1962 Summer Meeting in the West, Seattle, Aug. 1962.

An NMR system designed for very accurate control and measurement of magnetic fields from 1 to 13 kgauss in a combined magnetic spectrograph and spectrometer is described. The system features modular circuit construction and frequency modulation of the r-f oscillator. The principles of the system and the operating procedures are also given. (D.C.W.)

**27783** RADIATION CALIPER WELL LOGGING APPARATUS. Hugh E. Hall, Jr. and Ralph C. Reynolds (to Texaco Inc.). U. S. Patent 3,138,707. June 23, 1964. Filed Oct. 14, 1960.

A radiation logging instrument is designed for measuring the size of a borehold. The instrument comprises a housing to be passed into the borehole for measuring the influence of variations in the borehole size on the intensity of a gamma beam scattered in the borehole. A bow spring is provided for urging one side of the instrument against the side of the borehole, and the radiation detector is shielded against the radiation source. (D.L.C.)

**27784** DEVICE FOR RECORDING NUCLEAR RESONANCE SPECTRA. Dick Jan Kroon and Jan Volger (to North American Philips Co., Inc.). U. S. Patent 3,137,813. June 16, 1964. Priority date Oct. 20, 1959, Netherlands.

A device for recording nuclear magnetic resonance spectra is designed which gives accurate and reproducible spectra without the necessity for stabilization of the magnetic field and frequency. In operation of the device, a standard preparation is also placed in the first magnetic field, and this preparation in combination with a h-f oscillation generator provides a reference frequency which is compared with the field acting on the sample. Thus, a correcting voltage is produced which corrects the location of the absorption peaks in the spectrum. (D.L.C.)

**27785** METHOD OF CONTACTLESS INSPECTION OF NONMETALLIC COATINGS ON A METALLIC BASE. V. S. Vikhman, A. A. Naumov, and K. S. Plotnikov. Russian Patent 158,683.

A method of contactless inspection of nonmetallic coatings on a metallic base by means of a radioactive source of radiation that excites a characteristic radiation in the base and in the coating of an article being tested and ionizes the air gap between the radiation source and article is char-

acterized, in that, to simultaneously inspect thickness of the coating and its continuity, the latter is determined by the gas discharge which arises, in the presence of a discontinuity in the layer of the nonmetallic coating on the metallic base, between an electrode and radiation source, for example, tritium and the article being checked. (OTS)

## Radiation Detection

*Refer also to abstract 28484.*

**27786** (CEA-2335) ENSEMBLE DE COMPTAGE A ENREGISTREMENT AUTOMATIQUE (THESES). (An Automatic Counting and Recording System (thesis). Bernard Pierre (France. Commissariat a l'Enérgie Atomique. Centre d'Études Nucléaires, Saclay). 1963. 75p.

Submitted to Université, Grenoble, France.

An automatic control, counting, and programming system for the collection of single-crystal diffractometry data was designed for a neutron diffractometer in 1958 at C.E.N. Grenoble. A part of the whole instrument, the automatic counting and recording system, is described. Its applications are numerous and extensive, e.g., the system was designed for neutron diffractometer, but it can easily be adapted either for use with x rays or measurement of mean life in $\beta$ decay analysis. (auth)

**27787** (MLM-834) ABSOLUTE ALPHA COUNTING. I. DETERMINATION OF BACKSCATTERING FACTORS AND RANGES. M. L. Curtis and J. W. Heyd (Mound Lab., Miamisburg, Ohio). Apr. 10, 1953. Contract AT(33-1)-Gen-53. 9p.

A new, precise, and relatively simple method of studying the backscattering of alpha particles by means of absorption studies in a proportional counter is outlined. Its application to absolute alpha counting is extended to include corrections for self-absorption if the sample is not ideally thin. A simple, precise technique for alpha-energy determination is also described. The absorption method is shown to be useful in determining the proportions of two alpha emitters present in a mixture. (auth)

**27788** (ORNL-3578(p.1-5)) BASIC INSTRUMENTATION. (Oak Ridge National Lab., Tenn.).

Detectors having a 4-cc active volume were prepared, and their performance as gamma-ray spectrometers was evaluated. The detectors were superior to scintillation crystals in their response to gamma-ray energies below 200 kev. One technique that involves compensating steam-grown oxides for surface passivation of lithium-drifted detectors is described. Two schemes were devised for making measurements of the delayed light emitted by plants in the time region of $10^{-3}$ to $10^{-5}$ sec after illumination. (auth)

**27789** (ORNL-3578(p.37-45)) RADIATION MONITORING SYSTEMS. (Oak Ridge National Lab., Tenn.).

A fallout-monitoring system is described that consists of 44 stations located at strategic points in the Laboratory area. Each station consists of an alpha monitor and a beta-gamma monitor. Two pairs of telephone lines transmit analog signals, which indicate radiation level, and an a-c tone, which indicates the condition of the alarm levels. All alarm indicators are displayed at a central point. Only 12 of the analog signals are monitored; these are randomly selected until an alarm signal indicates that a certain station or stations should be selected. An iodine detector was developed for use with stack or duct particulate monitors. The detector consists of a charcoal trap and shielded G-M tubes. A detector installed at the 3039 stack has a good sensitivity for iodine and a fair sensitivity for xenon. A status summary is given of the installation of a central display panel and instruments and controllers for containment of radiochemical processing buildings. A tone telemetry system is described. With this system, a tone of fixed frequency is inserted onto a line carrying other signals and is extracted at a receiving end where display is made by means of lights. A memory permits sampling of many units on the receiving end. (auth)

**27790** (ORNL-3578(p.46-59)) RADIATION-DETECTION INSTRUMENTS AND COMPONENTS. (Oak Ridge National Lab., Tenn.).

A gas-flow proportional counter was designed to measure the uniformity and thickness of an alpha-emitting isotope being electroplated either upon a flat plate or inside small-diameter cylinders. Six different apertures were included in the detector collimator to extend the range of activities to be monitored. An alpha or beta-gamma monitoring instrument is designed that provides a 1-ma telemetering signal, a 10-mv strip-chart recorder signal, and an alarm or audible indication of count rate. A charge-sensitive amplifier at the input eliminates the need for preamplifiers for remotely located detectors. An instrument was developed that measures both the integrated gamma-ray dose and the rate of dose accumulation. Separate alarms are provided for each measurement. The integrating dosimeter is automatically reset every 8 hr. A portable GM counter was designed to record background counts at outlying stations. A PRM was designed to operate for 1 yr before battery replacement becomes necessary. A 5-in.-dia. parallel-plate fission chamber was designed and fabricated for experiments designed to measure $\alpha$ (the ratio of capture cross section to fission cross section) for $^{235}U$. An x-ray proportional counter was designed and fabricated to analyze the 5- to 35-kev photon ranges. The detector has beryllium windows on both sides and at its ends, and is filled to 79 cm pressure with Xe–10% $CH_4$ gas. For low-energy measurements, the x-ray beam enters through the side window, while for high-energy measurements, the counter is rotated 90° so that the beam may enter the end window. A gamma ionization chamber is described that may be used in radiation fields from 25 mr/hr to $10^5$ r/hr at low saturation voltages. The chamber is filled with high-pressure xenon and is contained in a stainless steel housing less than 1 in. in diameter. An ion chamber was designed to measure primary and secondary radiation inside a water-filled phantom. Dose measurements were made at different positions inside the spherical phantom while it was being irradiated by high-energy protons from an accelerator. A target and counter holder device is designed for experiments in neutron and proton spectroscopy. Experiments are conducted to provide verification of theoretical calculations for the design of radiation shielding for space vehicles. Functionally, the device is used to locate a cyclotron beam and to position detectors in a polar coordinate system about a target. The device also positions the target with its axis coincident with the beam axis. A dosimeter was designed to determine whether calculated radiation doses are in agreement with those measured with the dosimeter. The preparation and properties of lithium-drifted silicon radiation detectors prepared at ORNL are described. (auth)

**27791** (WCAP-2596) MINIATURE NEUTRON DETECTOR DEVELOPMENT. Quarterly Progress Report for Period, January 1–March 31, 1964. J. Weisman, ed. (Westinghouse Electric Corp. Atomic Power Div., Pitts-

burgh). Apr. 14, 1964. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(30-1)-2827. 22p. (EURAEC-1057)

Progress has been made in methods for the production of counting diodes. A two-step diffusion process for junction production is being developed. The diffusion of Al vapors into the SiC crystal is first carried out at ~900°C and is then followed by a short diffusion period at ~1600°C. This procedure is followed by heating the diode in a reducing atmosphere in order to increase the breakdown voltage while retaining the high-conductivity surface layer. Techniques for evaporating thin uranium films on SiC diodes are being developed. These films will enable the diodes to count neutrons by means of the fission fragments developed. The development of diode configurations for very high temperatures is reported. Success has been achieved in bonding the SiC crystals to Pt or W base tabs with a Pt–W alloy. Thermal cycling has shown the junction to remain ohmic. (auth)

**27792** FLASH TUBE DETECTORS. R. M. Bull, W. F. Nash, and B. C. Rastin (Univ. of Nottingham, Eng.). Contemp. Phys., 5: 180-97(Feb. 1964).

Flash tubes are finding increasing utility in high energy nuclear physics. They are easy to make and are particularly suitable for reliable particle detectors of large areas. A qualitative description of the construction, mechanism, and characteristics of flash tubes is given. The basic applications of the technique are appraised, with a simple account of the precision of measurement. The analysis of data for locating particle trajectories is discussed. Finally, flash tubes are compared with other detectors of similar performance. (auth)

**27793** I B I S. A FAST NEUTRON TIME-OF-FLIGHT SYSTEM. A. T. G. Ferguson (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Contemp. Phys., 5: 270-9(Apr. 1964).

The IBIS (Intense Bunched Ion Source) that was developed for neutron time-of-flight spectroscopy is described. IBIS consists of a 3-Mev Van de Graaff machine equipped with a pulsed ion source. The high-current radio-frequency ion source gives ~1 mamp of protons, deuterons, or helium ions in a beam that is chopped by sweeping in an elliptical path across an aperture. Current pulses of 10 nsec duration and repetition rate of 1 Mc are produced. Very high speed electronic circuitry measures the time interval between the arrival of the beam pulse at the target and the detection of the neutron in the detector. Applications of the instrument are illustrated. (C.E.S.)

**27794** A LIQUID SCINTILLATION COUNTER USING ANTICOINCIDENCE SHIELDING. G. J. Sprokel. IBM J. Res. Develop., 7: 135-45(Apr. 1963).

A liquid scintillation counter with an active volume of one liter is described. The plastic anticoincidence shield reduces background by about 25 percent in the $^{3}H$ and $^{14}C$ region. Photomultiplier noise is effectively eliminated by nanosecond coincidence circuitry. The tunnel diodes used in the coincidence arrangement also act as baseline or window discriminators. Counting efficiency for $^{14}C$ solutions is 85 percent, limited mainly by light collection. (auth)

**27795** A $\beta$-SPECTROGRAPH FOR STUDYING THE SPECTRA OF INTERNAL CONVERSION ELECTRONS EMITTED DURING CAPTURE OF A THERMAL NEUTRON BY A NUCLEUS. M. K. Balodis, V. A. Bondarenko, and P. T. Prokof'ev (Inst. of Physics, Academy of Sciences, Latvian SSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 262-7(Feb. 1964). (In Russian)

A $\beta$ spectrograph with a homogeneous, transverse magnetic field was installed in the face of a reactor. The target was placed in the active zone of the reactor, and an Al vacuum tube with an internal diameter of 13 cm and a length of 4 m penetrated the reactor shielding wall. A total of 7 cm of lead and 1.5 cm of boron carbide was used to decrease the background due to $\gamma$ rays and neutrons. The magnetic field was held constant from 50 to 300 Oe to within ±0.02%. The maximum deviation from a homogeneous field was ±0.1%. A wide beam of electrons was focused in the homogeneous, transverse magnetic field by introducing a magnetic screen. The resolution was at least 0.45% for various radii of curvature of the magnetic screen ($\rho$ = 10 to 40 cm). A Cd target with a thickness of 4 mg $cm^{-2}$ was inserted into the reactor, and the conversion electron spectrum was determined in a constant magnetic field of 200.02 Oe by darkening of a film by the electrons. After applying the proper corrections, the energies of the conversion electrons were tabulated for the $^{113}Cd(n,\gamma)^{114}Cd$ reaction. (TTT)

**27796** INTERFERENCE PHENOMENA WITH RESPECT TO TIME. D. A. Varshalovich (Ioffe Inst. of Physics and Tech., Leningrad). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 396-9(Feb. 1964). (In Russian)

Interference phenomena are considered on the basis of an imaginary experiment. As the result of a cascade transition, the nuclei of a source emit particles or quanta, designated as $r_1$ and $r_2$; a high-resolution analyzer is used to determine the energy of the $r_2$ particles that pass through a chopper. The shutter allows the particle to pass through only when they are recorded and the whole system is assumed to operate on a delayed-coincidence scheme with respect to $r_1$ and $r_2$. The considerations show that three types of determinations are possible in this system, depending on the delay time of the chopper and the effective resolution time of the detector. On the basis of quantum-mechanical considerations, in the generalized case, the intensities are not additive because of interference phenomena. Equations are derived for determining the intensity in the case of a spontaneous transition. The results of these theoretical tests are greatly dependent on the order in which the various steps are carried out. In the case discussed, interference is observed only if the time is measured first and the energy afterwards. The periodically operating chopper may be considered as a time-diffraction lattice. Such a lattice may serve for the detailed time study of quantum processes, for the measurement of the lifetime of a system in an excited state, and for the investigation of related phenomena. (TTT)

**27797** CHARACTERISTICS OF A LONG IONIZATION CHAMBER, AND ANOMALOUS RESPONSES NEAR THE GUARD TUBE. Kozo Tamura, Yoshihiko Kanamori, and Yutaka Furuta (Japan Atomic Energy Research Inst., Tokyo). Japan J. Appl. Phys., 3: 232-3(Apr. 1964).

A chamber with a Bakelite wall 55 cm in length and 2.5 cm in inside diameter was constructed; and its energy response, saturation current, and local response were measured. During measurement of the local response, anomalous responses were observed, for which explanations are proposed. (D.C.W.)

**27798** CERIC DOSIMETRY FOR HIGH ENERGY ELECTRON. Yohta Nakai, Koji Matsuda, Torao Takagaki, and Ki-ichi Kimura. Nippon Hoshasen Kobunshi Kenkyu Kyokai Nempo, 4: 7-12(1962). (In Japanese)

The G-value of the ceric sulfate dosimeter was found to be constant in the range of $3 \times 10^{-3}$ to $5 \times 10^{-3}$ M, and is shown by the equation, $G = 2.30 - 0.48\ X$, where $X = Ce^{3+}/(Ce^{3+} + Ce^{4+})$. When X was in the region between 0.25 and

0.75, the accuracy of the ceric sulfate dosimeter was less than 8%. If X is outside of this region, the stability and reproducibility of the ceric sulfate dosimeter become worse. Since the stability and reproducibility of the ceric sulfate dosimeter are disturbed by the presence of organic impurities in the solution, the most careful distillation of water is required. The limit of measurable dose was from $5 \times 10^6$ to $5 \times 10^7$ rads for electron beams. The effects of dose rate and temperature were found to be negligible. (P.C.H.)

**27799** THE PROBLEM OF IMAGE ACCURACY IN SCINTIGRAPHY. G. Nentwig, E. Dressler, and H. J. Correns (Friedrich-Schiller-Universitat, Jena, Ger.). Radiobiol. Radiotherap., 5: 121-8(1964). (In German)

The accuracy of scintigraphic reproductions of contours of organs and of areas of different activities within an organ with radioactive substances is essentially dependent on the dose applied, the degree of accumulation, the scanning rate, and on the properties of the collimators used. The different collimators are characterized by some parameters by means of which it is possible to select the collimator for the respective problems, as to search for metastases or thyroid deposition, which guarantees the optimum scintigraphic image. (auth)

**27800** THE INFLUENCE OF NON-POINT RADIATION SOURCES ON REPRESENTATION AND TRANSFER OF THE "ROENTGEN." K. Willuhn and M. Peschel (Deutsche Amt fur Messwesen und Warenprufung, Berlin). Radiobiol. Radiotherap., 5: 201-16(1964). (In German)

Starting from the conception introduced by Behnken of the effective measuring volume in the representation of the Roentgen by means of standard ionization chambers, a definition of this concept for the case of non-point radiation sources is given. It is demonstrated that the quantity of the effective measuring volume for point radiators which is computed from the diaphragm cross section of ionization chamber and the length of measuring electrode, is kept in using non-point radiation sources. The conditions for the exact transfer of the dose unit are examined resulting from the calculation of the relation between mean dose rate of a plan area taken as circular of the ionization chamber of a routine dosimeter and the cross section of the diaphragm aperture of the standard chamber. (auth)

**27801** DOSE-RATE METER SERIES. RADIATION PROTECTION INSTRUMENTS USING HALOGEN-QUENCHING EXTRA-SMALL GM TUBES. Shigeo Kobayashi, Toyoaki Takebe, and Masayuki Ionkoshi (Tokyo Shibaura Electric Co., Ltd.). Toshiba Rev. Intern. Ed., No. 17, 41-6(1964).

The design and performance of miniature GM-type dose-rate meters using halogen-quenching extra-small GM tubes with an enlarged measuring range are reported. The tube output is available in either pulse or current and with a long life. (C.H.)

**27802** A SPARK-CHAMBER SPECTROMETER FOR ENERGETIC PARTICLES IN SPACE. Richard Madey, Thomas Aggson, Robert Paige, and Peter Raft (Republic Aviation Corp., Farmingdale, N. Y.). Trans. Am. Nucl. Soc., 7: 15(June 1964).

**27803** A NEW CONFIGURATION FOR AN ELECTRICALLY ADJUSTABLE GAMMA-COMPENSATED IONIZATION CHAMBER. D. P. Roux, J. C. Gundlach, and S. H. Hanauer (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 54-5(June 1964).

**27804** ALPHA SCINTILLATION COUNTER, SAMPLE CHAMBER (Q-2287) (Engineering Materials). (Oak Ridge National Lab., Tenn.). (CAPE-1090)

This package contains 3 drawings. For a listing of individual titles, see the Engineering Materials List (TID-4100). The counter is used for counting smear samples. It was designed to be used with a standard G-M tube scaler. The smear sample is placed in a well 2 in. in dia. and 0.125 in. deep in a movable slide in the light-tight sample chamber. The slide is operated to position the sample under the detector. A ZnS(Ag) phosphor coupled with Scotch tape to the end of an RCA-6655A phototube serves as the detector. A double guard ring used as a light seal makes it possible to keep high voltage on the phototube at all times. Results gave a count rate that was 44% of the disintegration rate of a $^{239}$Pu source. Background for 4 to 5 hr was a minimum of 2.65 counts per hr and a maximum of 3.75 counts per hr. (F.S.)

**27805** RECTIFYING PROCESS IN SURFACE BARRIER DETECTOR. P. Siffert and A. Coche (Centre de Recherches Nucleaires, Strasbourg). 16p. (CONF-182-21)

From the 9th Scintillation and Semiconductor Counter Symposium, Washington, D. C., Feb. 1964.

The effects of various experimental conditions on the characteristics of silicon-n-gold contacts, particularly the inverse current, were studied. After preparation, slices of silicon-n were either immediately placed under vacuum for gold deposition or were allowed to stand in air before gold deposition, and the characteristics of the resultant contacts were examined. The effects of placing the slice back in vacuum after exposure to air, putting the slices in different gases after gold deposition, and placing the slices in electric fields were also studied. (D.C.W.)

**27806** THE DEVELOPMENT OF PHOTOMULTIPLIER TUBES FOR TRITIUM COUNTING. J. Sharpe and V. A. Stanley (EMI, Electronic Tube Div., CRI, Los Angeles). 29p. (CONF-182-22)

From the 9th Scintillation and Semiconductor Counter Symposium, Washington, D. C., Feb. 1964.

The procedures by which photomultipliers more suitable for low-energy beta counting were obtained are discussed. The characteristics of various tubes that were developed and the performance obtained with various counting head designs are also considered. Counting efficiencies of 10 to 15% at 20°C and 50 to 60% at −10 to −20°C can presently be obtained for 10 ml samples of tritiated toluene phosphors with a tube background of 3 counts/sec. (D.C.W.)

**27807** HIGH ENERGY NEUTRON DETECTOR WITH EVACUATED CHAMBER. Robert L. Staples, Robert R. Warnken, Jr., and Charles Herbert Gleason (Westinghouse Electric Corp.). U. S. Patent 3,137,792. June 16, 1964. Filed Apr. 1, 1960.

A neutron-sensitive device is designed with a low neutron sensitivity for operation at high fluxes up to $10^{16}$ n/cm$^2$/sec and with gamma compensation even where the gamma flux to neutron flux ratio is high. The device comprises a pair of evacuated chambers, each with a pair of electrodes and only one with a coating of a neutron-sensitive material on one electrode. Upon irradiation of the device by neutrons, positive fragments are formed by the coating and are collected by the other electrode. Since no gas fill is used and hence no gas ionization occurs, no collecting potential for low-energy ions is needed, and a low neutron sensitivity is obtained. Gamma compensation is obtained by comparing the output signals of the two chambers. (D.L.C.)

**27808** METHOD AND APPARATUS FOR DETERMINING CONTAMINATION OF A METAL BODY BY URANIUM. Richard J. Preston (to Combustion Engineering, Inc.). U. S. Patent 3,137,793. June 16, 1964. Filed July 17, 1959.

An apparatus is designed for determining the amount of U contamination of the surface of a metal body, e.g., clad fuel elements and control rods for reactors. The apparatus is based on alpha particle counting by the gas-flow proportional counting technique. U contamination as low as 1 ppm and as high as 1000 ppm can be detected. (D.L.C.)

**27809** GAMMA RAY SCINTILLATION DETECTORS WITH LIGHT CONDUCTING RODS FOR REACTOR HOT SPOTS. Benedict Cassen and Irving Ross (to Hycon Mfg. Co.). U. S. Patent 3,138,709. June 23, 1964. Filed Mar. 19, 1956.

A gamma radiation monitoring system which can stand up under high temperature to intense fluxes of fast neutrons and gamma rays, is designed for detecting the formation of hot spots in a reactor. The system comprises a plurality of pure fused silica detecting elements disposed throughout the reactor core to form a grid of points, bent light pipes leading from the elements through the reactor shield to photomultiplier tubes, and amplifier means connected between the photomultipliers and a center-balanced, two-position polarized relay. The relay operates lamps to indicate when a hot spot is formed or the temperature is too low in the reactor. (D.L.C.)

# ISOTOPE TECHNOLOGY

## General

**27810** (MLM-1183) MOUND LABORATORY PROGRESS REPORT FOR JANUARY 1964. J. F. Eichelberger, G. R. Grove, and L. V. Jones (Mound Lab., Miamisburg, Ohio). Jan. 31, 1964. Contract AT(33-1)-Gen-53. 30p.

Separation processes were evaluated for the removal of uranium-234 from aged plutonium solutions, and uranium from nitric acid solutions. An analytical method was investigated for uranium in the presence of cationic impurities. A thermal loading pump for filling cylinders with purified $^{3}He$ gas was tested. An apparatus for determining thermomolecular pressure corrections for $^{3}He$ gas vapor pressure was evaluated using $^{4}He$ gas. Isotope separation studies were conducted for carbon and neon using thermal diffusion methods, and for xenon using gas chromatography. An approximate formula for the viscosity of a binary, isotopic gas mixture was derived from the rigorous kinetic theory formula. Methods were developed for the fabrication of alpha and neutron sources. Coating materials are being evaluated for use in storage of thorium residues. Design and calibration studies were made of control circuits for calorimetry equipment. Properties measurements are reported for thermosetting plastic materials, and for flexible conductive adhesives. (B.O.G.)

**27811** (ORNL-TM-198) ISOTOPES DIVISION QUARTERLY REPORT, OCTOBER–DECEMBER 1961. J. H. Gillette (Oak Ridge National Lab., Tenn.). June 5, 1962. Contract [W-7405-eng-26]. 39p.

Customer services performed are discussed. Calculations were made to determine the effect of irradiation time and flux on the isotopic ratios of fission product cesium. Experiments related to the production of $^{159}Dy$, $^{68}Ge$, $^{71}Ge$, $^{103}Pd$, and $^{99}Mo$ were conducted. The extraction behavior of tributyl phosphate, diamyl amylphosphonate, and dihexyl hexylphosphonate was investigated. The precipitation of cesium as cobaltinitrite was accomplished. A fused-salt system for the isotopic enrichment of $^{137}Cs$ and $^{87}Rb$ was studied. A program was initiated to recover uranium from Homogeneous Reactor Test fuel. Over 80,000 liters of deuterium gas was produced by electrolysis of deuterated water. The diethylenetriaminepentaacetic acid ion-exchange system for the separation of $^{147}Pm$ from the other fission rare earths was tested. Various source preparations and the preparation of cesium borosilicate glass are discussed. The investigation of the $^{60}Co$ thermoelectric generator was continued. The feasibility of preparing a $^{90}Sr$ heat source, of $8 \times 10^{5}$ curies, was studied. Information concerning the status and progress of engineering development is given. In the thermal-diffusion facilities, the operation of $^{36}Ar$, neon, and $^{124}Xe$ columns and the development of the $^{13}C$ columns were continued. Data relative to isotope separations including calutron operation, calutron charge preparation, chemical refinement, and special electromagnetic separations are listed. Information on ion beam studies, the inhomogeneous field separator experiment, and ion source studies is given. Target development and routine fabrication of targets by evaporation, rolling, and electrodeposition are discussed. (auth)

**27812** (ORNL-TM-415) ISOTOPES DIVISION RESEARCH AND DEVELOPMENT REPORT, MAY 1962. J. H. Gillette (Oak Ridge National Lab., Tenn.). Dec. 18, 1962. Contract [W-7405-eng-26]. 24p.

Progress is reported on developments in the preparation and properties measurements of radioisotopes, radioactive sources, calutrons, and thermal diffusion studies in radioactive gases. (B.O.G.)

**27813** (ORNL-TM-428) ISOTOPES DIVISION RESEARCH AND DEVELOPMENT REPORT, JUNE 1962. J. H. Gillette (Oak Ridge National Lab., Tenn.). Jan. 9, 1963. Contract [W-7405-eng-26]. 20p.

Progress is reported on: developments in methods for the production of radioisotopes and radioactive source materials; the development and operation of calutrons; thermal diffusion studies in isotopic gases; and the development and fabrication of radiation target materials. (B.O.G.)

**27814** (ORNL-TM-434) RADIOACTIVE SOURCE DEVELOPMENT. Isotopes Development Center Progress Report, July–September 1962. E. E. Beauchamp, comp. (Oak Ridge National Lab., Tenn.). Jan. 7, 1963. Contract [W-7405-eng-26]. 4p.

The development of cesium glass radiation sources is discussed. An evaluation of the properties of $CdO-Cs_2O-Li_2O-SiO_2$ glass is presented. The development of promethium-147 and iodine-125 x-ray source is summarized with respect to preparation, fabrication, and radiation properties. (N.W.R.)

**27815** (ORNL-TM-718) TARGET DEVELOPMENT. Isotopes Development Center Progress Report, April–September 1963. E. H. Kobisk, comp. (Oak Ridge National Lab., Tenn.). Jan. 16, 1964. Contract [W-7405-eng-26]. 14p.

High-temperature systems for heating vapor sources were developed to meet requirements imposed in the evaporation of refractory metals and oxides. These systems are capable of generating temperatures in excess of 2000°C at low electrical power input. The two types of heat systems studied were electrical resistance and electron bombardment. Crucibles to be used with the electron bombardment system were designed to collimate vapors and significantly decrease losses of valuable isotopic material during thin film production. As much as a 100-fold improvement in vapor condensation was realized by this technique. Tritium target fabrication studies were initiated to improve the amount of tritium available to generate neutrons by (d,n) reaction and secondly to increase the life of the tritium target at high-target temperatures. Special stable isotope targets of magnesium and scandium having coating thicknesses of 5 mils on a copper substrate were studied. These targets will be employed in cyclotron-produced isotope experiments. Self-supporting films of germanium, antimony, and sulfur were prepared in thicknesses less than 1000 $\mu g/cm^2$. Sulfur films were subject to phase change and could not be used after 24 hours. During this period, 517 targets were produced, a 30% increase as compared to the number produced during the same period last year. Of these targets 437 were fabricated from stable isotopes; 42 were tritium targets prepared by sorption of the gas on evaporated layers of zirconium, yttrium, or titanium; and 38 were thin-film targets formed by evaporation-condensation of fluorides or bromides of plutonium, uranium, or radium. (auth)

## Industrial Applications

**27816** (IAN-A-1) PRESERVACION DE TUBERCULOS DE PAPA POR MEDIO DE RADIACIONES GAMMA. (Pres-

ervation of Potatoes by Gamma Irradiation). M. A. Perdomo, J. A. Hernandez, and J. Sanin (Colombia. Instituto de Asuntos Nucleares, Bogota). Jan. 1963. 18p.

The Tocarreña and Pardo Pastusa varieties of potatoes tubers were irradiated with $^{60}Co$ at a dose rate of 860 rads/h/m to total doses of 5, 7.5, 10, and 15 kilorads. These were stored with unirradiated tubers at 10 ± 2°C for 8 months. It was found by analysis that irradiated samples did not show any unfavorable changes in the quality of the product. The best dose for preservation was about 10 kilorads and the Pardo Pastusa variety gave the better response. (auth)

**27817** (PA-TM-1271) AN APPROACH TO THE USE OF RADIOISOTOPES IN SALT SPRAY TESTING. C. G. C. White and E. F. Stevenson (Picatinny Arsenal. Feltman Research Labs., Dover, N. J.). June 1964. 16p.

Salt spray testing is a general qualitative technique used to evaluate metal surface protective coatings. The conclusions drawn from such testing are at present arbitrary since comparisons are made with standards which are sometimes not well defined and which depend upon individual judgment for determining conformity with specifications. Since salt spray testing simulates the effects of several types of corrosion, it was felt that a welding of the techniques used in measuring such corrosion with radioisotopic techniques might prove fruitful in making the salt spray test more quantitative. The uses of radioisotopes to study corrosion mechanisms, corrosion rates, surface phenomena, etc., and launching an investigation into quantitative salt spray testing are discussed. (auth)

**27818** (PB-181469) UTILIZATION OF ISOTOPES FOR SALINE WATER CONVERSION. Research and Development Progress Report No. 68. (Chance Vought Corp., Dallas). Dec. 1962. 298p.

A study was conducted of the use of radioisotope power as a heat source for saline water conversion. An economic feasibility study was made on this type of energy. The most economical source appears to be from the calcined fission product waste from processed spent reactor fuel elements. The results indicated that, for special conditions, this source of heat is competitive with conventional fuels. Results are presented of various studies on compatibility, thermodynamics, nuclear, and materials aspects of a full-scale heater utilizing calcined radioisotope waste products. The studies have permitted the conceptual design of a nuclear heater capable of supplying the thermal requirements for a one million gallon per day saline water conversion operating at 200 kwh/1000 gal. The design of a laboratory test model is given. The model will be capable of producing 250 gallons per day using one megacurie of cerium-144 and a six-stage flash evaporation conversion unit. A hazards analysis of the test model is included. (auth)

**27819** (TID-20708) THE APPLICATION OF NUCLEAR ENERGY TO AGRICULTURE. Annual Report. Carl C. Moh (Inter-American Inst. of Agricultural Sciences, Turrialba, Costa Rica). July 1, 1964. Contract AT(30-1)-2043. 76p.

Progress is reported on studies in biochemistry and plant physiology, radiation botany, cytogenetics and mutation in beans, sterilization of the Mediterranean fruit fly, and biology of the tropical warble fly and method of control. Separate abstracts have been prepared for four sections of the report. (C.H.)

*For abstracts of individual papers see: 27016, 27017, 27070, and 27071.*

**27820** POTENTIAL BETA-GAUGE APPLICATIONS IN THE TEXTILE INDUSTRY. Otto Teszler, S. Ogawa, and Henry A. Rutherford (North Carolina State Coll., Raleigh). Am. Dyestuff Rptr., 21-5(Jan. 23, 1961).

An attempt was made to show the usefulness of a beta gage as a means for measuring weight (mass per unit area) nondestructively. Experiments were conducted using the beta gage for measurements of wet pick-up, extent of drying, fabric uniformity, and fabric abrasion or wear. There are many other operations in the textile industry where the instrument can conceivably be used, but no attempt has been made to study the various applications exhaustively. Rather, emphasis was placed on the establishment of principles on the basis of which complete systems capable of measurement and automatic control can be developed. (auth)

**27821** NUCLEAR APPLICATIONS IN THE DETERMINATION OF THE VOLUME OF WATER IN THE SOIL. A HUMIDITY MEASURING INSTRUMENT WITH NEUTRONS. J. Marcesse. Eau, L, 50: 287-92(May 1963). (In French)

Studies were carried out in order to devise a humidity measuring instrument, based on neutron moderation, that would be light, simple, inexpensive, and suited to the requirements of agronomists. As a result of these investigations, the apparatus, which fulfills these specifications and is being manufactured on a commercial scale, consists of a sounding rod of 39 mm diameter comprising a 5-mC Ra–Be fast neutron source, a thermal neutron detector, and a preamplifier. The sounding rod is connected electrically with an integrator comprising an amplifier, 2 electric sources of 10 and 2000 v, respectively, and a microammeter. The 5-mC Ra–Be source emits 75000 fast n/sec which are moderated by the medium through which they pass, especially by the collision with the H atoms of water, and converted into thermal neutrons which can be counted by a $BF_3$-filled counting tube. The electric pulses produced are amplified to 10 v and integrated to produce and electric current, which can be read at a dial of an ammeter of 25 $\mu$ amp. In order to translate the readings into actual humidity percentages, the apparatus is calibrated with material of a known water content such as sand and water. (OID)

**27822** RADIOISOTOPES AS TRACERS IN HYDROLOGY AND HYDRODYNAMICS. G. Grandclément. Eau, L, 50: 293-300(May 1963). (In French)

The advantages of radioactive tracers in comparison with other methods applied in hydrology consist of the wide choice of radioisotopes available, their applicability in situ, their extreme sensitivity, their rapid dispersion, and their fast disappearance. The greatest drawback is their absorption and retention by chemical or physical processes. The $\beta$ and $\gamma$ emitters usually used are $^{198}Au(\beta,\gamma)$; $^{82}Br(\beta,\gamma)$; $^{60}Co(\beta,\gamma)$; $^{51}Cr(\gamma)$; $^{131}I(\beta,\gamma)$; $^{106}Ru(\beta,\gamma)$; and $^{3}H(\beta)$. The salts $Na^{131}I$ or $Na^{82}Br$, or the EDTA complexes of $^{60}Co$ or $^{51}Cr$ dissolve instantly in water and can be readily detected in concentrations of $10^{-6}$-$10^{-4}$ g/cu ml with NaI(Tl) scintillation counters. The classical forms of application are: determination of the connection between water bodies or water containing layers; measurement of velocity or direction of flow; estimation of hydrologic properties of water containing bodies; determination of the magnitude of ground-water reserves; measurement of the water balance between water bodies; study of water diffusion in geological strata, and retention and mixing in natural and artificial reservoirs; and detection of water leakages. The natural

tritium content of water bodies can be used for determining the age of the water. (OID)

**27823** LIQUID LEVEL INDICATOR MVH-1. Jaromir Kuba and Adolf Uncovsky (Research Inst. for Metallurgy of Iron, Brno, Czechoslovakia). Jaderna Energie, 10: 136-8(Apr. 1964). (In Czech)

Liquid level indication is one of the most frequently used applications of radioisotopes. In metallurgy of steel, liquid level control is the basis for automatic continuous casting of steel. The liquid level indicator MHV-1 was developed specifically for this purpose. The instrument is described; its source of gamma radiation is discussed. The calibration curve for the instrument is shown. The accuracy is within 5 mms. (OTS)

**27824** RAPID DETERMINATION OF THE SOIL DENSITY AND THE MOISTURE CONTENT. W. G. de Jager. Polytech. Tijdschr., 18: 842b-5b(Oct. 16, 1963). (In Dutch)

An instrument is described for the simultaneous determination of density and humidity of soil surface layers down to a depth of 30 cm. The apparatus consists of a combination of the density measurement devices that pick up reflected $\gamma$ radiation from a Ra or Cs source and, at the same time, measure the slowing down of the neutron flux emitted from a Po–Be source. The $\gamma$ rays are counted with a gas-filled Geiger counter, while the slowed-down neutrons are counted by a Geiger counter filled with $BF_3$ gas. Other instruments, based on the same principle, were built into the depth meter and allowed the measurement of soil density and humidity up to 60 m depth. All of the instruments are full transistorized and portable. The electric current is produced by batteries. The construction of this apparatus is described. The main features of instruments of American, Dutch, German, and Swiss origin were compared on the basis of an actual soil test. (OID)

**27825** PRIMENENIE RADIOAKTIVNYKH IZOTOPOV DLIA KONTROLIA KHIMICHESKIKH PROTSESSOV. (The Application of Radioisotopes for the Control of Chemical Processes). R. V. Kzhagatspanian, R. F. Romm, and L. K. Tatochenko. Moscow, Gos. Nauchno-Tekh. Izd-vo Khimicheskoi Literatury, 1963. 344p.

Instrument theory for radiation counters was developed, and the application of these instruments for the control and regulation of chemical-technological processes is discussed. Methods of determining and recording nuclear radiations are described along with protective measures against the radiation. The properties of gas-filled ionization chambers, gas discharge counters, crystal dielectric and semiconductor counters, and scintillation detectors using inorganic or organic phosphorus were evaluated, along with their design properties. The various circuits involved in the radioisotope counting equipment are diagramed and explained. Applications for automation of the processes of chemical technology, such as level control, control and regulating of extraction columns by a $\gamma$ densitometer, concentration control, Cl and O processing, crystal growing, and others are summarized. (OID)

**27826** THE DEVELOPMENT AND SOME APPLICATIONS OF COBALT-60 IRRADIATORS. R. F. Errington (Atomic Energy of Canada Ltd., Chalk River, Ont.). 14p. (CONF-539-2)

From Canadian Nuclear Association Conference on Canada's Role in a World of Expanding Nuclear Industry, Toronto, May 1964.

The development of gamma irradiation devices and facilities for medical and industrial purposes is reviewed, together with applications in medical research, material modification, food preservation, and sterilization. Some information on the design of the facilities and the results of their utilization is also included. Future uses and their benefits are indicated. (D.C.W.)

## Power Application

**27827** CONSTRUCTION OF A PROMETHIUM-147 ATOMIC BATTERY. H. Flicker (RCA Labs., Princeton, N. J.), J. J. Loferski, and T. S. Elleman. IEEE (Inst. Elec. Electron. Engrs.), Trans. Electron Devices, ED-11: No. 1, 2-8(Jan. 1964).

The feasibility of constructing an atomic battery by combining the $\beta$-emitting radioisotope $^{147}Pm$ and a semiconductor containing a p-n junction was studied both theoretically and experimentally. The properties of cells made by diffusing a p-type impurity into n-type GaAs, p-impurity into n-type Si (p/n), and n-impurity into p-type Si (n/p) were compared. The problems associated with the presence of an $\alpha$ emitting impurity ($^{241}Am$) in the $^{147}Pm$ and with the fabrication of a suitable $^{147}Pm$ source were considered. Experiments with prototype batteries composed of $^{147}Pm$ and n/p Si cells led to the conclusion that such batteries would have a half life (1.6 yr) somewhat shorter than that of $^{147}Pm$ (2.6 yr). Such a battery could generate a few mw of power from a volume of about 2 $in.^3$ including shielding. (auth)

**27828** THE USE OF Ac-227 AND Th-228 IN RADIOISOTOPE HEAT AND NEUTRON SOURCES. J. M. Gerhart and C. P. Ruiz (General Electric Co., Pleasanton, Calif.). Trans. Am. Nucl. Soc., 7: 132-3(June 1964).

**27829** INTEGRATED SPACE THRUSTOR USING RADIOISOTOPE AUXILIARY POWER. David F. Berganini and Charles W. Glassburn (Air Force, Wright-Patterson AFB, Ohio). Trans. Am. Nucl. Soc., 7: 133(June 1964).

**27830** THE RADIOISOTOPE-POWERED, BIMETALLIC-DISK ENGINE. Calvin C. Silverstein (Hittman Associates, Inc., Baltimore). Trans. Am. Nucl. Soc., 7: 134(June 1964).

## Separation and Production

*Refer also to abstracts 27296 and 27754.*

**27831** (ORNL-3606) REVIEW OF ORNL ELECTROMAGNETIC SEPARATIONS PROGRAM, JANUARY–DECEMBER 1963. L. O. Love and W. A. Bell (Oak Ridge National Lab., Tenn.). May 1964. Contract W-7405-eng-26. 53p.

Developments and activities of the Electromagnetic Isotope Separations Department for 1963 in areas of magnetic fields, ion sources, ion receivers, charge evaluation, contamination, system modifications, quality control, and chemistry are reviewed. Both stable isotope separations and special heavy element separations are included. (auth)

**27832** (ORNL-TM-530(Rev.)) REACTOR- AND CYCLOTRON-PRODUCED ISOTOPES. Isotopes Development Center Progress Report, November–December 1962. T. A. Butler, comp. (Oak Ridge National Lab., Tenn.). Aug. 28, 1963. Contract W-7405-eng-26. 20p.

A method of dissolving metallic foils (~0.001 in.) in varying concentrations of HCl (3.2N, 6.5N, 9.7N and 12.2N) by alternating current electrostripping is described. Under the conditions described, the amount of metal electrostripped in 30 min was found to be, in $mg/in.^2$ 80 (Rh), 900 (In), 90 (Pd), 2.5 (Au) and 12 (Ir). The production of $^{84}Rb$ utilizing the $^{87}Sr(p,\alpha)^{84}Rb$ and the $^{84}Kr(p,n)^{84}Rb$ reactions in the ORNL 86-Inch Cyclotron is described. A

production rate of 3.3 μc $^{84}$Rb/hr was found in the irradiation of SrO at a beam current of ~180 μa. A gas target assembly for the irradiation of Kr gas (normal and $^{86}$Kr depleted) is described. The average production rate from the proton irradiation of Kr was found to be 0.23 mc/hr, 1.1 mc/hr, and 0.5 mc/hr for $^{83}$Rb, $^{84}$Rb, and $^{86}$Rb activities. The thick target reaction cross section at 12.9 Mev was estimated to be ≤4300 mb, ≤1900 mg, and ≤2200 mb, for the $^{83}$Kr(p,n)$^{83}$Rb, $^{84}$Kr(p,n)$^{84}$Rb, and $^{86}$Kr(p,n)$^{86}$Rb reactions, respectively. The production of $^{57}$Co by the irradiation of nickel with 23-Mev protons is discussed. The preparation and irradiation of high purity, low-Co content Ni targets are described. Details are given for the electrostripping of the Ni target and the isolation and purification of the $^{57}$Co activity. $^{57}$Co activity was obtained with a specific activity of ≥7.2 mc/μg Co. (auth)

**27833** PURITY CONTROL OF RADIOISOTOPES. THE SEPARATION OF TELLURIUM NUCLEAR ISOMERS BY PAPER CHROMATOGRAPHY. F. Dobici and F. Salvetti (CNEN, Rome and Università, Rome). J. Inorg. Nucl. Chem., 26: 911-13(June 1964).

The separation of $^{127}$Te and $^{129}$Te nuclear isomers by paper chromatography is described. The dibutyltelluride, formed from tellurite during isomeric transition in a medium of HCl–butyl alcohol, travels with the solvent front while the tellurite shows a $R_f = 0.60$. (auth)

**27834** THERMAL DIFFUSION IN TERNARY MIXTURES. III. HYDROGEN AND HELIUM ISOTOPES. F. Van der Valk (F.O.M. Laboratorium voor Massascheiding, Amsterdam). Physica, 30: 729-40(Apr. 1964).

By extending the previous equations to quaternary mixtures, thermal diffusion factors for the mixtures $H_2$–HD–$^3$He–$^4$He and $H_2$–$D_2$–$^3$He–$^4$He were calculated, using the (exp-6) model. It is assumed that the Chapman-Enskog theory (for spherical molecules without internal degrees of freedom) can be applied to the hydrogenic molecules. It turns out that, for all concentration ratios of the components, the mixture $^4$He–HD–$^3$He–$H_2$ will arrange in that order from cold to hot in a temperature gradient whereas for the mixtures with $D_2$ instead of HD the sequence will be: $D_2$–$^4$He–$^3$He–$H_2$. The results for the addition of $^4$He to a mixture of $H_2$ with a trace of $D_2$ is compared with the calculation of Hellund for the rigid elastic spheres. (auth)

**27835** ISOTOPIC EQUILIBRIUM IN H–D SYSTEM OF GASEOUS HYDROGEN AND HYDROGEN SOLUTION IN PALLADIUM. B. M. Andreev and V. M. Tsionskii (Moscow Chemical Technological Inst.). Zh. Fiz. Khim., 38: 751-2(Mar. 1964). (In Russian)

The separation coefficient of hydrogen isotopes in a mixture of H and D in equilibrium with hydrogen dissolved in palladium was studied as a function of the temperature. In the temperature range 20 to 120°C, the heat of the isotopic exchange reaction is 1080 cal/atom, with the heat of reaction decreasing at lower temperatures. The separation coefficient as a function of pressure increases with diminishing pressure. (R.V.J.)

**27836** SEPARATION OF THE ISOTOPES AND SPIN ISOMERS OF THE MOLECULAR HYDROGENS BY PREFERENTIAL ADSORPTION AT LOW TEMPERATURES. Walter Jennings Haubach, Jr. Thesis. Columbus, Ohio, Ohio State Univ., 1963. 113p.

The isotopic and spin isomer separation of homo and heteronuclear diatomic molecules was investigated experimentally by two methods: desorption experiments and chromatographic experiments. Both sets of experiments were performed at low temperatures (14 to 77°K) by using non-catalytic (with respect to spin conversion) gamma alumina as the adsorbent. The desorption experiments demonstrated qualitatively that: the isotope separation was governed by a zero point effect; the spin isomer content affected the isotope separation; and the magnitude of the separation factors was that predicted by the theory of White and Lassettre. The chromatographic experiments were performed with conventional equipment using a column approximately six inches long containing nearly two grams of gamma alumina. Neon was used as the elution gas to gain sensitivity in the thermal conductivity cell. The sample volume had a large effect on the retention time, as might be expected on a heterogeneous surface; this effect was studied in detail. Various fractions of a monolayer of xenon were preadsorbed on the surface in an attempt to decrease the dependence of the retention time on the volume. It was not possible to completely homogenize the surface in this manner; however, the volume effect was considerably reduced. By comparing retention times for the various isotopic and ortho-para species at the same volume, it was possible to obtain separation factors at a common surface coverage. The data fitted a Freundlich isotherm and were linearized by plotting log retention time vs. log sample volume. The order of volatility of the species investigated is para-hydrogen > ortho-hydrogen > hydrogen deuteride > hydrogen tritide > ortho-deuterium > para-deuterium. By using experimental values of the isosteric heats of adsorption of para-hydrogen on gamma alumina to choose the barrier height for the molecule-surface interaction (depth of the well of a Morse potential), separation factors were calculated, and good agreement between theory and experiment was obtained. (Dissertation Abstr., 24: No. 11, 1964)

**27837** ELECTROMAGNETIC SEPARATION OF ISOTOPES IN A SMALL LABORATORY MACHINE. O. Almen. Thesis, Chalmers Univ. of Tech., Gothenburg, Sweden, 1962. 40p.

Problems encountered using laboratory isotope separators are discussed. Ion sources, ion beam formation, and collection technique, are considered. It was concluded that the introduction of the retardation method has greatly improved the collection technique in a laboratory isotope separator. (P.C.H.)

**27838** ISOTOPES PRODUCTION PLANT (Engineering Material). (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). (CAPE-1050)

This package contains 36 drawings. For a listing of individual titles, see the Engineering Materials List (TID-4100). The conceptual design for the isotope production plant consists of a circular process building 140 ft in dia and 69 ft high with an attached single-story service building 100 × 120 ft. The process building contains a circular, concrete-shielded structure 103 ft in dia, which is divided into 11 manipulator cells and eight process vaults. The eight wet chemistry cells are located below grade level. Six of these are ~15 ft deep; two cells, including the pool and solvent extraction column cells, are ~26 ft deep. These vaults are accessible from the top by a crane through removable, 5 ft 4 in. thick concrete cover blocks. The cell floors are lined with stainless steel, and the walls and cover blocks are coated with radiation-resistant paint. Each of the manipulator cells is 16 ft high. These cells are accessible by crane from the top and through doors in the back of the cells. Shielded pass-throughs are used to transfer material from the cell access area into the cells. The plant will be capable of high-volume pro-

duction of encapsulated heat sources of $^{90}Sr$, $^{137}Cs$, $^{144}Ce$, and $^{144}Pm$. (F.S.)

**27839** IMPROVEMENTS IN OR RELATING TO FLUID DIFFUSION APPARATUS. Serge Depaule and Michelle Vulpillat (to Commissariat a l'Energie Atomique). British Patent 960,712. June 17, 1964. Priority date Mar. 30, 1960, France.

A device for the separation of isotopic fluids by diffusion is designed which is readily disassembled for replacing the diffusion elements. The device comprises a sealed enclosure with three apertures (one as inlet for fluid to be diffused and two as outlets for the separated fractions of fluid) and a plurality of diffusion elements in the form of flat boxes. (D.L.C.)

# MATHEMATICS AND COMPUTERS

*Refer also to abstract 28094.*

**27840** (AD-411772) A PROBLEM OF RANDOM ACCELERATIONS. Wendell H. Fleming (Wisconsin. Univ., Madison. Mathematics Research Center). June 1963. Contract DA-11-022-ORD-2059. 26p. (MRC-TSR-403)

The partial differential equation yu(x) + u(yy) = 0 is solved in a vertical strip. The method is first to solve the equation in the upper and lower halves of the strip. By matching u and u(y) across the x-axis a singular integral equation for u(x) (x,0) is obtained. This is converted into an equation with a Cauchy kernel, the solutions of which are known explicitly. (auth)

**27841** (AEEW-M-424) AN ANALYSIS OF ZEEP REACTION RATE MEASUREMENTS USING THE ITERATIVE FIVE-GROUP SCHEME OF METHUSELAH I. F. R. Allen and J. R. Askew (United Kingdom Atomic Energy Authority. Reactor Group. Atomic Energy Establishment, Winfrith, Dorset, England). Feb. 1964. 22p.

The five-group iterative scheme of METHUSELAH I was used to provide estimates of reaction rates for comparison with measurements in a number of loop experiments in ZEEP. Theory and experiment show good agreement for individual fission rate distributions and for the Pu-239/U-235 reaction rate ratios. Estimates of Lu/Mn ratios are in reasonable agreement with measurements in the $H_2O$ cores, but become progressively less satisfactory as the $D_2O$ content of the coolant is increased. It is concluded that for assessment calculations, the introduction of an iterative five-group scheme improves the representation of thermal spectra in pressure tube reactor lattices. (auth)

**27842** (AEEW-R-369) FLIRT—A FORTRAN LANGUAGE 1-DIMENSIONAL REACTOR TRANSIENT PROGRAMME. M. E. R. Veale and H. E. Wrigley (United Kingdom Atomic Energy Authority. Reactor Group. Atomic Energy Establishment, Winfrith, Dorset, England). Mar. 1964. 41p.

A computer program for solving the few-group, time-dependent, one-dimensional (axial), diffusion equation with general scatter matrix is described. Auxiliary equations representing heat transfer, xenon production, and control rod movements are solved in conjunction with the diffusion equation. The heat transfer equations relate specifically to a re-entrant AGR. The equations and methods of solution are discussed, and a detailed description of the method of reduction of the three-dimensional diffusion equation to a one-dimensional form is given. This method of deducing the one-dimensional diffusion equation introduces extra terms designed to give the correct axial leakage. (auth)

**27843** (HW-81076) THE USE OF REDUCED DELAYED NEUTRON GROUP REPRESENTATIONS IN NUCLEAR REACTOR SIMULATION. R. W. Albrecht and C. Metelmann (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Mar. 2, 1964. Contract AT(45-1)-1350. 21p.

A computer program is described for IBM 7090 for calculating reduced group constants for cases of subcritical reactor transfer functions. A system of four equations is solved. Magnitudes and phases of the transfer functions for a $^{239}Pu$ system and for a $^{235}U$ system with prompt neutron lifetimes of $10^{-5}$ and $10^{-3}$ sec, respectively. (R.E.U.)

**27844** (LAMS-3075) TEWA—AN IBM CODE FOR COMPUTING THE MAXWELLIAN DOPPLER BROADENING OF BREIT-WIGNER RESONANCES. Lee Bordwell, Joseph J. Devaney, Marjorie Devaney, Bertha Fagan, and Max Goldstein (Los Alamos Scientific Lab., N. Mex.). June 28, 1961. Contract W-7405-eng-36. 74p.

TEWA 2 is an IBM 704 code for folding a three-dimensional Maxwellian velocity into sums of single level Breit-Wigner resonance formulas. Linear level-level interference in elastic scattering is included. The results of TEWA are printed on listings and on magnetic tape and are punched on cards. The cards serve as input to COMANCHE-SUM-3 which reduces isotopic results to results for the normal element or for mixtures of isotopes. The programs and their operation are outlined. (auth)

**27845** (NAA-SR-7929) ANALYSIS OF POWER RAMPS WITH AN ANALOG COMPUTER. W. J. Carlson and A. L. Gunby (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). June 15, 1964. Contract AT-11-1-GEN-8. 39p.

Analysis of power ramps on the Sodium Reactor Experiment by use of the analog computer is a fast, accurate, and simple method for determining the heat transfer parameters. This method requires a minimum of reactor time. Results on the SRE Core II are reproducible to ±5%, showing a prompt power coefficient of reactivity of −2.05 ¢/Mwt at 1000 gal/min main-primary flow. The single-lag temperature feedback approximation is adequate for most operating conditions of the reactor. (auth)

**27846** (ORNL-3578(p.60-6)) DATA HANDLING AND COMPUTATION. (Oak Ridge National Lab., Tenn.).

Commercial components were assembled into a digital system for neutron time-of-flight studies. Resolution of the time-interval meter is 10 nsec with a maximum time span of 4 μsec. An experimental model of an automatic control system for scanning reactor fuel plates was fabricated and tested. A collimated x-ray beam scans a fuel plate, and a scintillation detector detects variations of transmitted x-ray intensity to indicate the fuel distribution as well as total fuel within a plate. The readout is a printed paper tape and a strip-chart record. Changes and additions to ORNL data-logging facilities are described. Several codes are described which make use of frequency techniques for a variety of control and analysis problems. Interface programming is defined and the special problems associated with computer input programs for data-logging systems are discussed. The EGCR control-rod-prototype test and the proposed methods of data reduction are presented. A computer program was developed to facilitate the calibration of thermocouples. (auth)

**27847** (ORNL-3592) AN APPROACH TO ALGOL TRANSLATION. A. A. Grau and L. L. Bumgarner (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 85p.

The approach to Algol translation described is an extension and elaboration of that given in The Structure of an Algol Translator (ORNL-3054). In machine-independent form are given specifications for a translator for Algol 60. These specifications have been obtained in the design and construction of The Oak Ridge Algol Compiler for the Control Data Corporation 1604 (ORNL-3460). They may also be used with little modification to give an Algol translator for any present-day sequential machine. (auth)

**27848** (SC-R-64-122) POLYCRYSTALLINE FERROELECTRIC MULTIREMANENCE MEMORY ELEMENTS.

C. E. Land, G. W. Smith, and I. D. McKinney (Sandia Corp., Albuquerque, N. Mex.). Mar. 1964. Contract AT(29-1)-789. 22p. (CONF-401-2)

From Institute of Electrical and Electronics Engineers 1964 International Convention, New York, Mar. 1964.

In contrast to biremanence or bistable memory elements, the multiremanence element is capable of storing information in any one of several distinguishable states. A number of different configurations of multiremanence elements, each possessing continuous nondestructive readout capability, were constructed using hot-pressed, rhombohedral, lead–zirconate–titanate ceramics. The simplest storage element configuration is a two-terminal bar or disk resonator. Information is stored into the element by switching the polarization by a fixed number of increments. The resulting stable polarization state is read out nondestructively by monitoring the small-signal immittance of the resonator. When certain constraints are placed upon the useful range of polarization and frequency of the interrogating signal, the two-terminal small-signal immittance of the resonator becomes a smooth monotonic function of remanent polarization. If the maximum switching field is restricted to less than twice the coercive field, the immittance-polarization relation becomes essentially anhysteretic. The correlation between small-signal immittance and polarization permits detection of at least ten storage states using quite simple readout circuits. More storage states are made available with increased sophistication in readout circuits. The material, switching, and readout characteristics, as well as the stability of the storage states of ferroelectric multiremanence memory elements are discussed. (auth)

**27849** (SC-TM-282-63(74)) A THIN-FILM ELECTROCHEMICAL MEMORY CELL. C. N. Kelly and C. J. Rogers (Sandia Lab., Albuquerque, N. Mex.). Nov. 1963. Contract AT(29-1)-789. 10p.

A report on the preliminary investigation of a thin-film memory device and does not describe in detail how the device is constructed. Both the basic techniques used in constructing a solid-state thin film memory device and some of the device's typical characteristics are described. The device requires no standby power, has very low input power requirements, and has two definite states. Its general usefulness is limited by its slow switching speed. (auth)

**27850** (TID-20663) TECHNICAL PROGRESS REPORT. PART I. HIGH-SPEED COMPUTER PROGRAM. PART II. ILLIAC II SYSTEM PROGRAMMING, MAINTENANCE AND OPERATION. PART III. CIRCUIT RESEARCH PROGRAM. PART IV. IBM 7094-1401 SYSTEM. PART V. GENERAL LABORATORY INFORMATION. (Illinois. Univ., Urbana. Digital Computer Lab.). Feb. 1964. Contract AT(11-1)-415. 56p.

Installation of Flow Gating Bootstrap is reported. Completed design of Special Register 32 to be used to recover from Interrupt of "Add to Next" information is reported. Operation and maintenance of ILLIAC II are discussed. Development of coupled transmission lines and analysis of triggering properties of tunnel diodes for nanosecond pulse amplifier and OR gate are discussed. Hot electron diodes, photo-coupled circuits, and tunnel diode theory are included. Fifty-two problems were submitted to the IBM 7094, and are described briefly. (R.E.U.)

**27851** (UCRL-7687) COMPLEX: A LEAST SQUARES METHOD FOR FITTING QUADRATICALLY INTERPOLATED TABLES TO A TWO-DIMENSIONAL DATA ARRAY. Richard H. White (California. Univ., Livermore. Lawrence Radiation Lab.). Jan. 30, 1964. Contract W-7405-eng-48. 18p.

Equation of state data (pressures and energies as functions of temperatures and densities) at LRL are rendered amenable to calculations on a digital computer by tabulating the functions on a rectangular grid and interpolating quadratically in both independent variables to find values of the function at points off the table grid. A method developed for fitting such tables to a large data array is outlined. The table format and method of quadratic interpolation are also discussed. (D.C.W.)

**27852** AN IDENTITY INVOLVING 9-j COEFFICIENTS. James D. Talman and William W. True (Univ. of California, Davis). Can. J. Phys., 42: 1081-6(June 1964).

An identity involving 9-j coefficients, which may be of some value in spectroscopic calculations, is obtained. Two proofs of the identity are described. In one proof, the recoupling of matrix elements of tensor operators is considered; in the other, the general methods of Yutsis are used. Two applications of the identity to nuclear shell-model theory are described. (auth)

**27853** CONVERSION OF A POWER TO A SERIES OF CHEBYSHEV POLYNOMIALS. Henry C. Thacher, Jr. (Argonne National Lab., Ill.). Comm. ACM (Assoc. Computing Machinery), 7: 181-2(Mar. 1964).

Even slowly convergent power series can be rearranged as series in Chebyshev polynomials if appropriate sequence transformations are used in evaluating the coefficients. The method is illustrated by computing the coefficients for the expansion of the logarithm and dilogarithm. (auth)

**27854** SOME ASYMPTOTIC FORMULAS FOR THE LEGENDRE FUNCTIONS $P_\nu^\mu(\cos\theta)$ AND BESSEL FUNCTIONS $J_\nu(x)$ FOR SMALL $\theta$ AND x. Russell A. Bonham (Naval Research Lab., Washington, D. C. and Indiana Univ., Bloomington). J. Math. Phys., 40: 282-8(Dec. 1961).

Asymptotic series expansions for approximately the Legendre functions by Bessel function and for approximating Bessel functions are derived. Asymptotic forms for the spherical Bessel and Neuman functions are obtained as a limiting case of the latter. Numerical results are compared. (D.C.W.)

# METALS, CERAMICS, AND OTHER MATERIALS

## General

**27855** (HW-75065) SUBSURFACE DISCONTINUITIES IN N-REACTOR CARBON STEEL PIPE WELDS. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Nov. 1963. Contract AT(45-1)-1350. 40p.

After part of the large-diameter, high-pressure carbon steel pipe required for the primary loop had been manufactured it was found that the longitudinal welds contained subsurface cracks of the shrinkage or hot-tear variety not detectable through the use of ordinary x-ray or ultrasonic inspection techniques. The larger cracks found by destructive testing measured up to ½ in. perpendicular to the plane of fusion between the weld and base materials. In metallurgical investigations performed by pipe manufacturers, it was learned that cracks of this kind, which apparently exist to some extent in all pipe of this size and type, could be minimized under a quality control program representing the manufacturer's "best effort." A set of special requirements specifying that the cracks be limited in number and size to that corresponding with "best effort" performance were established. Pipe manufactured from then on, or pipe from earlier lots that could be repaired, met those special requirements for acceptance. In the course of the investigation a large number of destructive tests were made. The probable number, distribution, and size of the cracks were studied statistically, and a thorough fatigue testing program was carried out for the purpose of evaluating primary loop integrity. The information from these tests indicated that weld cracks permitted for the "best effort" production runs were acceptable for application of pipe in the primary loop, and the fatigue testing program revealed that the accepted pipe did not have any appreciable reduction in fatigue strength compared with specimens containing unflawed welds. (auth)

**27856** (HW-79280(p.9.1-4)) MATERIALS DEVELOPMENT, CORROSION, AND HEAT TRANSFER STUDIES. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

ZIRCONIUM ALLOY STUDIES; Water Environment. Order of magnitude increases in corrosion rates are attributed to $10^{14}$ nv fast fluxes (>1 Mev) in ETR irradiations of Zircaloy-2 specimens in water at 270°C. STAINLESS STEEL, NICKEL-BASE, AND ALUMINUM ALLOY STUDIES; Alloy Selection. Alloy Selection. Damage Mechanisms. ATR Gas Loop Oxidation Studies. Oxidation of Superalloys in Contaminated Flowing Helium at 1038°C. PRTR MATERIALS DEVELOPMENT; Oxidation and Deuterium Absorption of Zirconium Alloys in $D_2O$ at pD 10 LiOD. Corrosion and Hydriding of Prehydrided Zircaloy-2. Corrosion of Stainless Steel in a Monosodium Phosphate Solution. PRTR Pressure Tubes. Ten pressure tubes were discharged from the PRTR for destructive testing. Aluminum Corrosion and Alloy Development. (auth)

**27857** (HW-80284(p.9.1-3)) MATERIALS DEVELOPMENT, CORROSION, AND HEAT TRANSFER STUDIES. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Corrosion of Zircaloy-2 by irradiated water coolant from the ETR G-7 loop was studied. Haynes 25 Alloy was evaluated for possible use as structural material in the ATR gas loop. Deuterium absorption by zirconium and Zircaloy-2 in 275°C $D_2O$, observation of fretting corrosion of PRTR pressure tubes, and destructive examination of a PRTR pressure tube flow are reported. (R.E.U.)

**27858** (IITRI-B6007-6) [DISPERSION-STRENGTHENED VANADIUM ALLOYS]. Final Report, December 14, 1962–December 13, 1963. F. C. Holtz and L. B. Richard (Illinois Inst. of Tech., Chicago. IIT Research Inst.). Jan. 10, 1964. Contract N600 19 59567. 34p. (AD-427343)

Vanadium–niobium base alloys containing additions of titanium, zirconium, or hafnium in combination with up to 0.2 wt % carbon were prepared by arc-melting and fabricated to sheet for elevated temperature creep tests. Compositions based on V-60Nb and containing titanium or zirconium with carbon had good fabricability, but V-60Nb-1Hf-C and V–40Nb–30Ta–C alloys were difficult to work. Creep tests conducted on siliconized specimens in 2000°F air showed that large carbon additions (0.1 and 0.2 wt %) produced increased creep rates in V–60Nb base alloys. The most creep resistant composition was V–60Nb–10Ta–1Zr–0.075C which exhibited 1.25% creep in 2.5 hours under a stress of 11,200 psi. (auth)

**27859** (KAPL-2000-21) REACTOR TECHNOLOGY REPORT NO. 24—METALLURGY. (Knolls Atomic Power Lab., Schenectady, N. Y.). May 1964. Contract W-31-109-eng-52. 101p.

Eight papers are presented on the following topics: closure welds and fatigue strength in omega seals, descaling of Inconel, thermal expansion of $La_2O_3$ and $Nd_2O_3$, fatigue properties of weld-deposited Inconel, brazing alloys, corrosion of Zircaloy-2 containing $O_2$ and $N_2$, properties of Nb–Cr alloys, and evaluation of a power source for automatic welding of seals. Separate abstracts were prepared for all eight papers. (D.L.C.)

*For abstracts of individual papers see: 27860, 27861, 27883, 27884, 27915, 27916, 27957, and 27958.*

**27860** (KAPL-2000-21(p.I.1-11)) EFFECT OF CLOSURE WELD CONFIGURATION ON THE FATIGUE STRENGTH OF OMEGA SEALS. R. R. Gatts and G. J. Sokol (Knolls Atomic Power Lab., Schenectady, N. Y.).

Sections of Ni–Cr–Fe Alloy 600 omega seals with various amounts of weld metal drop-through were fabricated into specimens and subjected to cyclic strains corresponding to cyclic radial displacements of an omega seal in service. Comparison of the strain ranges which would be expected to be associated with the lives required to produce cracking in smooth omega sections and in omega sections with pronounced drop-through, indicated an effective strain concentration factor of 2¼ due to drop-through. This effect was relatively independent of the extent of drop-through for both depth and breadth of the drop-through zone. In general, cracking was initiated at a notch associated with the weld metal drop-through. The cracks propagated across the specimen so as to produce the shortest crack path. There was no observable tendency for the crack path to be influenced by the weld heat-affected zone or the weld–base-metal interface. (auth)

**27861** (KAPL-2000-21(p.VII.1-5)) SELECTED PROPERTIES OF NIOBIUM–CHROMIUM ALLOYS. F. W. Kunz and A. P. Beard (Knolls Atomic Power Lab., Schenectady, N. Y.).

Furnace-cooled and fast-cooled specimens of Nb–1.57 wt % Cr alloy were prepared for property determinations. Tensile properties, hot hardness, and creep were measured. The thermal expansion was found to be compatible with these of Nb and Nb–6 wt % V. Corrosion tests were conducted in 1500-psi steam at 750 to 900°F; the results show slow-cooled Nb–1.57 wt % Cr to be superior to Nb and fast-cooled Nb–1.57 wt % Cr. (D.L.C.)

**27862** (NASA-SP-41(p.313-16)) PROBLEMS RELATED TO COMPATIBILITY TESTING. B. ENVIRONMENT (PURIFICATION OF ARGON FOR GLOVE BOXES AND ENVIRONMENTAL CHAMBERS). M. F. Parkman (Argonne National Lab., Ill.).

The efficiency of Ti–50 at. % Zr in removing $O_2$ from Ar was studied. For a 60 ppm $O_2$ feed concentration at 1200°F, the outlet concentration was less than 1 ppm $O_2$. A molecular sieve trap followed by a Ti–50% Zr hot trap resulted in Ar containing <1 ppm $O_2$ and ~2 ppm $H_2O$. A NaK bubbler produced Ar containing 2.5 ppm $O_2$ and 1.7 ppm $H_2O$. The performance of a vacuum glove box containing neoprene gloves was studied using Ar containing 4 ppm $O_2$ and 8 ppm $H_2O$. The results showed that, while the $O_2$ content remained low, the $H_2O$ content increased, particularly when the gloves were used with bare hands. (D.L.C.)

**27863** (NUMEC-2389-1) DEVELOPMENT OF PLUTONIUM-BEARING FUEL MATERIALS. Progress Report, October 1–December 31, 1963. (Nuclear Materials and Equipment Corp., Apollo, Penna.). Contract AT(30-1)-2389. 40p.

Coprecipitated $UO_2$–$PuO_2$ were prepared and characterized to supply feed material for sintering studies and physical property measurements. Powder mixtures of $UO_2$–$PuO_2$ and $UO_2$–$ThO_2$ were prepared by dry ball milling, twin shell blending, and plow blending for comparison with the standard wet ball milling, but satisfactory homogeneity was not obtained. $UO_2$–$PuO_2$ samples were reduced at 700 and 1150°C in a thermobalance, and good reproducibility was obtained. The effects of addition of two sintering aids, SrO and $Y_2O_3$, on the density and electrical resistivity of $PuO_2$ were determined. In sintering studies on coprecipitated $UO_2$–35 wt % $PuO_2$ pellets, densities of >95% theoretical were readily obtained over a wide range of conversion temperatures. In mechanically blended $UO_2$–$PuO_2$, alumina impurity had no effect on the sintered density, and a more detailed study was made of the sintering characteristics. Oxidation of coprecipitated and blended $UO_2$–$PuO_2$ pellets was studied and compared, and oxygen diffusion equations were derived. Thermal expansion coefficients of $ThO_2$, $UO_2$, and $PuO_2$ were determined from lattice parameter measurements at temperatures up to 1200°C. Sintering characteristics of $UO_2$–$PuO_2$ pellets for use in high burnup irradiation tests, are listed. (D.L.C.)

**27864** (ORNL-3577) USE OF MICRORADIOGRAPHY COMBINED WITH METALLOGRAPHY FOR EVALUATION OF COATED PARTICLES. R. W. McClung, E. S. Bomar, and R. J. Gray (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 16p.

The proposed use of nuclear fuels coated with pyrolytic carbon has made it necessary to devise techniques for evaluating them. Metallographic techniques, modified to accommodate the spherical particle configuration, have proved quite useful for observing the structure of both the cladding and the core. For nondestructive examination, special low-voltage radiographic techniques have been developed. By employing extremely fine grained photographic emulsions, optical magnification can be used to make very accurate measurements of the core diameter and coating thickness, and, in addition, the core and coating integrity can be evaluated. The combination of the methods permits the use of the best feature of each toward the evaluation of coated particles. (auth)

**27865** (ORNL-3616) DIFFUSION OF TITANIUM-44 AND VANADIUM-48 IN TITANIUM. James F. Murdock (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 74p.

The diffusion behavior of titanium-44 and vanadium-48 in body-centered cubic titanium was studied over the temperature range 900 to 1550°C using lathe sectioning and gamma spectrometry to determine the activity-distance profiles. Extensive use was made of the CDC 1604 and the IBM 7090 digital computers in analyzing the experimental data. It was found that the Arrhenius-type equation, $D = D_0 \exp(-Q/RT)$ with constant Q and $D_0$, did not adequately describe the temperature dependence of the diffusion coefficient. The data for both titanium-44 and vanadium-48 result in a plot of ln D versus 1/T which gives a continuously curving line over the entire temperature range. The apparent activation energies and frequency factors calculated from the slopes of those curves were found to increase with temperature. Computer-fitting the experimental ln D versus 1/T plot by the method of nonlinear least squares yielded the following equations which describe the behavior: $D_{Ti}{}^{44} = 3.58 \times 10^{-4} \exp(-31{,}200/RT) + 1.09 \exp(-60{,}000/RT)$ and $D_V{}^{48} = 3.10 \times 10^{-4} \exp(-32{,}200/RT) + 1.37 \exp(-57{,}200/RT)$. Three possible explanations of the observed behavior are discussed: that the activation energy is a temperature-dependent function for a single mechanism; that diffusion along short-circuit paths predominates at low temperatures; and that there may be two or more competing volume diffusion mechanisms. The proposed model of Kidson is seen to qualitatively explain the data. However, with the presently available data, no single explanation of the observed anomaly can as yet be ruled correct. (auth)

**27866** (WADD-TR-61-72(Vol.XIII)) RESEARCH AND DEVELOPMENT ON ADVANCED GRAPHITE MATERIALS. VOLUME XIII. DEVELOPMENT OF A FINE-GRAIN ISOTROPIC GRAPHITE FOR STRUCTURAL AND SUBSTRATE APPLICATIONS. R. A. Howard and E. L. Piper (National Carbon Co. Advanced Materials Lab., Lawrenceburg, Tenn.). Sept. 1963. Contract AF33(616)-6915. 34p.

A description is given of the development, fabrication, and physical properties of grade RVC graphite (formerly designated as experimental grade RT-0029). Grade RVC has been manufactured in sizes up to 18 inches in diameter by 15 inches in length and is nominally characterized by a bulk density of 1.81 g/cc, an admittance to $N_2$ of $2 \times 10^{-2}$ and $6 \times 10^{-3}$ $cm^2$/sec w.g. and a.g., respectively, and a room temperature flexural strength w.g. and a.g. of 2560 and 1930 lbs/$in.^2$, respectively. RVC is an excellent substrate material for silicon carbide coatings because its thermal expansion between 400 and 1000°C is approximately 0.3% in both grain directions. This expansion is in the same range as that for silicon carbide. Results are also presented on high temperature oxidation of silicon carbide-coated grade RVC specimens. The unusually good oxidation protection afforded the graphite by the coating demonstrates the marked superiority of this substrate over other graphite materials which do not match the silicon carbide in thermal expansion. (auth)

**27867** (WADD-TR-61-72(Vol.XXXVIII) RESEARCH AND DEVELOPMENT ON ADVANCED GRAPHITE MATERIALS. VOLUME XXXVIII. DEVELOPMENT OF AN

IMPROVED LARGE-DIAMETER ULTRAFINE-GRAIN GRAPHITE. R. A. Howard and R. L. Racicot (National Carbon Co. Advanced Materials Lab., Lawrenceburg, Tenn.). Oct. 1963. Contract AF33(616)-6915. 25p.

A description is given of the development, fabrication processes, and physical properties of grade RVD graphite (formerly RT-0008), 18-inch diameter by 15-inch length, and an attempted scale-up of this grade to 33-inch diameter. Grade RVD graphite, an extra-fine-grain material formed by pressure curing, is nominally characterized by a density of 1.87 to 1.89 g/cc and flexural strengths of 4700 lb/in.$^2$ with the grain and 3100 lb/in.$^2$ across the grain. Nozzles made from RVD graphite, tested in a subscale rocket motor, exhibit a low erosion rate and high thermal shock resistance. (auth)

**27868** (WADD-TR-61-91(Pt.IV)) NONDESTRUCTIVE METHODS FOR THE EVALUATION OF CERAMIC COATINGS. W. E. Lawrie and M. D. Oestreich (Illinois Inst. of Tech., Chicago. IIT Research Inst.). Mar. 10, 1964. Contract AF33(657)-8938. 59p.

This report describes the investigation of methods to evaluate the quality of ceramic and intermetallic coatings used to provide increased oxidation resistance for refractory metals. A survey conducted during the course of the program indicated that the parameters of importance were (a) coating thickness, composition, and uniformity, (b) the position, lateral extent and depth of cracks, and (c) the presence of voids, pinholes, and other discontinuities in the coating. The measurement of coating thickness, and of layer thickness in multilayer coatings, is being approached by beta backscatter measurements. Nuclear methods for determining coating uniformity and the presence of cracks or other discontinuities are also being studied. The ultrasonic investigations have been directed exclusively at the application of Rayleigh wave methods to coating evaluation. (auth)

**27869** (SC-T-64-910) ON THE ZIRCONIUM OXIDE AS AN ELECTROLYTE FOR ELECTROCHEMICAL RESEARCH AT ELEVATED TEMPERATURES. Hermann Schmalzried. Translated by Marcel I. Weinreich (Sandia Corp., Albuquerque, N. Mex.), from Z. Elektrochem., 66: 572-6(1962). 12p.

It is shown by x-ray intensity measurements that Ca ions, which are added to the $CaF_2$-phase of $ZrO_2$ (+CaO), occupy statistically the (000) + fcc-sites, and according to the amount of Ca ions vacancies are formed in the anion sublattice. Between 700 and 1000°C, the transport number of excess electrons in $ZrO_2$ (+CaO) is determined by emf measurements as a function of the oxygen partial pressure. A simple setup for measuring oxygen partial pressures as low as $10^{-22}$ atm is described, and further application of $ZrO_2$ (+CaO) as a means for determining ionic transport numbers in oxides is discussed. (auth)

**27870** ON THE PREPARATION OF THIN ORIENTED FILMS OF ZIRCONIUM AND THEIR OXIDATION. Michel Denoux and Jean-Jacques Trillat (CNRS, Bellevue, France). Compt. Rend., 258: 4683-6(May 11, 1964). (In French)

Thin films of zirconium were deposited on NaCl and $CaF_2$ by electron bombardment vaporization. Several forms of orientation were observed. The oxidation of the films in air at a pressure of $10^{-5}$ mm of Hg was studied at temperatures below 500°C, the zirconia initially formed on the films is originally cubic, but slowly evolves into the monoclinic form. The transformation also occurs with heating above 600°C. The relative orientations of the metal and oxides are described. (D.C.W.)

**27871** A METHOD OF GROWING PERFECT MONOCRYSTALS OF REFRACTORY METALS. L. S. Starostina, V. N. Kachinskii, and N. A. Brilliantov (Inst. of Crystallography, Academy of Sciences, USSR). High Temp., 1: 276-7(Sept.-Oct. 1963). (Translated from Teplofiz. Vysokikh Temp., 1: 310-12(Sept.-Oct. 1963)).

A description is given of an apparatus for making perfect monocrystals of W, Re, Ta, Nb, Mo, V, and Zr by zone melting under vacuum; an electron beam provides the heat. The degree of perfection is deduced from $\rho_{300°K}/\rho_{4.2°K}$; the Hall effect as measured on a specimen of highly pure W gives some indication of the Fermi surface. (auth)

**27872** MOBILITY OF METAL PARTICLES ON A GRAPHITE SUBSTRATE. J. M. Thomas (University Coll. of North Wales, Bangor) and P. L. Walker, Jr. J. Chem. Phys., 41: 587-8(July 15, 1964).

The movement of metal particles on the cleavage {0001} faces of graphite crystals at temperatures of 630 to 850°C in a variety of gases was investigated. Particles of silver and tantalum were observed to execute rotary motion about an axis perpendicular to the graphite surface. Random translatory motion was also observed. Particles of iron, cobalt, nickel, and manganese remained immobile for periods of several hours. Cobalt was observed to carve out channels a few microns deep across the graphite surface. (C.E.S.)

**27873** STUDY OF THE POSSIBILITIES OF PRODUCING METALLIC ZIRCONIUM BY IGNEOUS ELECTROLYSIS FROM ZIRCONIUM OXIDE. C. Decroly, A. Fontana, and R. Winand (Université Libre, Brussels). Mem. Sci. Rev. Met., 61: 287-98(Apr. 1964). (In French)

It is shown that it is possible to produce Zr by electrolysis of Zr oxide dissolved in a mixed bath of Na fluoride and Zr fluoride in the presence of C. However, attempts to reduce the O content below 1.7%, the current output being 70%, have not been successful. (P.C.H.)

**27874** PARTICLE WAVES AND PHONON FISSION IN CRYSTALS. E. R. Fitzgerald (Johns Hopkins Univ., Baltimore). Phys. Letters, 10: 42-?(May 15, 1964).

The concept of waves of length $\lambda = h/mv$ associated with moving particles is extended to the internal generation of such waves as a result of the acceleration of atoms in narrow field-free regions in a crystal when an external mechanical load is applied. The field-free atoms result from dislocations, vacancies, or other defects, and after attaining a velocity v in a very short time the free atoms of the crystal then propagate through the crystal lattice as wave packets. Phonon fission, i.e., breaking of the lattice, is also discussed. It is shown that self-sustaining fission or fracture conditions are possible. (C.E.S.)

**27875** SOME PROBLEMS IN ELECTRON BEAM MELTING. H. Gruber, W. Dietrich, E. Erben, J. Heimerl, and H. Stephan (W. C. Heraeus GmbH, Hanau, Ger.). Vakuum Tech., 12: 65-77(Apr. 1963). (In German)

The reliability of electron beam (EB) generating systems, requirements for an ideal electron gun, current systems comparison, power limitations with Pierce-type guns, future possibilities in EB melting and casting, skull melting and continuous casting, charging of EB melting furnaces, load locks, viewing problems in EB melting, and results of melting refractory metals with the Heraeus processes are discussed. (auth)

**27876** URANIUM. J. H. Gittus. Metallurgy of the Rarer Metals. 8. Washington, D. C., Butterworths, 1963. 637p. $24.75.

Information is included on: ores; detection, exploration,

and mining; ore concentration; manufacture of uranium metal and its compounds; fabrication; physical properties; deformation and preferred orientation; recovery, recrystallization and grain growth; mechanical properties; effects of pile irradiation; thermal cycling; gaseous and aqueous corrosion; alloys of uranium; diffusion; and metallography. Data on reactors, nuclear cross sections of the elements; periodic table of the elements; conversion tables, and maximum permissible doses from external radiation are appended. (P.C.H.)

**27877** REFRACTORY METAL COMPOUNDS. William Julian Kramers, Walter Bradshaw, James Raymond Smith, Roland Perce Sinden, and Philip Sydney Rogers (to United Kingdon Atomic Energy Authority). British Patent 960,720. June 17, 1964. Filed Aug. 28, 1958.

A group of refractory metal compounds called hydro compounds is described which may be used as reactor moderators at high temperatures. The hydro compounds have hydrogen dissociation pressures and comprise a metal (Zr, Ti, or rare earths), a non-metal (N, C, or O) forming a crystal lattice with the metal, and hydrogen in amount at least 0.25 (preferably 0.5) atoms per atom of metal, the hydrogen being chemically bound in the lattice and displaceable without disrupting the lattice. Ca, Li, or Pu may be added in small amounts to the metal to modify the neutron absorption properties. The compounds may be prepared by heating a metal hydride with a refractory metal oxide, carbide, or nitride in the presence of hydrogen at high temperatures. Examples of such compounds are Ce hydro-oxide, Zr hydro-nitride, Zr hydro-carbide, Ce hydro-oxysulfide, Li Zr hydro-oxide, etc. Some of their properties are tabulated. (D.L.C.)

**27878** REDUCTION OF ZIRCONIUM AND HAFNIUM TETRACHLORIDES WITH LIQUID MAGNESIUM. Hermann Renner (to Deutsche Gold- und Siber-Scheideanstalt). U. S. Patent 3,137,568. June 16, 1964. Filed May 31, 1961.

A process for producing Zr metal by Mg reduction of $ZrCl_4$ is given in which the side reaction $2ZrCl_4 + Mg \rightarrow 2ZrCl_3 + MgCl_2$ is prevented from taking place. The process comprises placing solid Mg covered by an alkali metal halide in a reaction vessel, diffusing $ZrCl_4$ vapors into the molten alkali metal halide to form a solution at a temperature below the melting point of Mg, and heating the reaction vessel to melt the Mg whereby $ZrCl_4$ in the solution is reduced to Zr sponge at the interface between Mg and the solution. The process is also applicable to the production of Hf metal. An apparatus for carrying out the process is described. (D.L.C.)

**27879** RADIATION RESISTING GLASS COMPOSITION. Dominick Labino (to Johns-Manville Fiber Glass Inc.). U. S. Patent 3,138,561. June 23, 1964. Filed date July 1, 1957.

A glass composition is given which resists radiation and high temperature and can be formed into glass fibers of submicron diameters for use as insulation. The glass comprises 37 to 45% PbO, 45 to 50% $SiO_2$, 11 to 13% alkaline oxides, and 2 to 4% $B_2O_3$. The alkaline oxide is preferably $Na_2O + K_2O$. An apparatus for forming fibrous glass from the above composition is described. (D.L.C.)

## Corrosion

*Refer also to abstract 27817.*

**27880** (APEX-760) RESULTS OF SOME LABORATORY WATER VAPOR CORROSION TESTS OF BeO. Period Covered: January 1961–April 1961. D. G. Salyards (General Electric Co. Flight Propulsion Lab. Dept., Cincinnati). July 31, 1961. Contracts AF33(600)-38062 and AT(11-1)-171. 25p.

Some experimental corrosion rates were determined for unfueled, uncoated BeO tubes at temperatures of 1800°F, 2150°F, and 2600°F in moist air, and are compared to the theoretical corrosion rates. With one exception all tests were run at the mass flow rate of 0.0023 lb/sec and a water vapor content of 0.76 percent by weight. The experimental test apparatus and techniques are described. (auth)

**27881** (CEA-R-2423) COMPATIBILITE DES ACIERS AU CHROME–ALUMINIUM AVEC LE GAZ CARBONIQUE SOUS PRESSION AUX TEMPERATURES MOYENNES. (The Compatibility of Chromium–Aluminium Steels with High-Pressure Carbon Dioxide at Intermediate Temperatures). Daniel Leclercq, Henri Loriers, René David, and Raymond Darras (France. Commissariat à l'Énergie Atomique. Centre d'Études Nucléaires, Saclay). Apr. 1964. 30p.

With a view to their use in the exchangers of nuclear reactors of the graphite-gas or heavy water-gas types, the behavior of chromium–aluminum steels containing up to 7% chromium and 1.5% aluminum was studied in the presence of high-pressure carbon dioxide at temperatures of between 400 and 700°C. Two grades of steel (2% Cr–0.35% Al–0.35% Mo and 7% Cr–1.5% Al–0.6% Si) were still compatible with carbon dioxide up to 550 and 600°C, respectively. A hot-dip aluminized coating considerably increased resistance to oxidation of the first grade and should make possible its use up to temperatures of at least 600°C. (auth)

**27882** (GEAP-4473) OXIDATION MECHANISM OF ZIRCONIUM AND ITS ALLOYS. II. OXIDE PLASTICITY. D. L. Douglass (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). Feb. 20, 1964. Work Performed Under United States–Euratom Joint Research and Development Program. Contract AT(04-3)-189. 20p. (EURAEC-1078)

The question of how crack-free, protective oxide films can form on zirconium during oxidation when the Pilling-Bedworth ratio is about 1.5 was considered by a study of the relative plasticity of various forms of zirconia. Hot hardness measurements showed that doping monoclinic zirconia with iron, nickel, or chromium resulted in softer (more plastic) structures and that yttrium additions slightly reduced the plasticity. Calcia-stabilized cubic zirconia was found to be more plastic than monoclinic zirconia when tested at temperatures above 200°C. The behavior of anion-deficient oxides indicated that they were more plastic than stoichiometric oxides even though the hardness values were identical at 23°C. The former were free from cracks at the indentations, whereas, stoichiometric oxides exhibited extensive cracking around and between indentations. The behavior of actual, thick (72 microns) oxide films during tensile deformation of oxidized metal samples indicated that considerable plasticity occurs in the oxide at 500°C but that the films are brittle at 23°C. It was concluded that the plasticity of the oxide may be greater than that of the oxygen-contaminated substrate at elevated temperatures and may be the means by which epitaxial strains are minimized. (auth)

**27883** (KAPL-2000-21(p.II.1-13)) ELECTROLYTIC DESCALING OF Ni–Cr–Fe ALLOY 600. C. Groot, A. S. Covert, and C. L. Crenshaw (Knolls Atomic Power Lab., Schenectady, N. Y.).

In studies of corrosion rates of Inconel, the adherent corrosion products must be removed before the coupons are weighed, usually by a cathodic treatment in sulfuric acid in conjunction with other treatments. Preliminary experiments, most of which were carried out on uncorroded blanks, were used to answer several questions concerning the balance accuracy, inhibitor, current density, nitric acid dip, reflectance, etc. Modifications to the procedure were made, and the new procedures for cathodic sulfuric-acid descaling of Inconel are given. (D.L.C.)

**27884** (KAPL-2000-21(p.VI.1-4)) CORROSION RESISTANCE OF CONSOLIDATED ZIRCALOY-2 CONTAINING OXYGEN AND NITROGEN. A. E. Bibb (Knolls Atomic Power Lab., Schenectady, N. Y.).

Coupons of compacted Zircaloy-2 powder containing 1800 to 6000 ppm $O_2$ and 100 to 400 ppm $N_2$ were exposed to oxygen-free 680°F water and 750°F steam for periods from 14 to 140 days. In the 680°F water corrosion tests, increases of $O_2$ or $N_2$ content shortens the time to transition from parabolic to linear rate. In the 750°F steam corrosion tests, $N_2$ has a deleterious effect on the corrosion rate. $O_2$ also has an adverse effect, but it is not as pronounced as that of $N_2$. (D.L.C.)

**27885** (NASA-SP-41) PROCEEDINGS OF THE NASA-AEC LIQUID-METALS CORROSION MEETING. VOLUME I. [HELD AT] LEWIS RESEARCH CENTER, CLEVELAND, OHIO, OCTOBER 2-3, 1963. (National Aeronautics and Space Administration, Washington, D. C.). 1964. 318p.

See NASA-SP-42 for Vol. II.

Twenty-three papers are presented on the mechanisms of liquid-metal corrosion, the results of compatibility tests with alkali metals, and the problems related to compatibility testing with alkali metals. Separate abstracts were prepared for 22 of the papers. (D.L.C.)

*For abstracts of individual papers see: 27657, 27862, 27886, 27887, 27888, 27889, 27890, 27891, 27892, 27893, 27894, 27895, 27896, 27897, 27898 27899, 27900, 27901, 27902, 27903, 28046, and 29147.*

**27886** (NASA-SP-41(p.21-6)) LIQUID-METAL CORROSION AS A SOLUTION PHENOMENON. John R. Weeks (Brookhaven National Lab., Upton, N. Y.).

The dissolution in static systems of pure metals is discussed. It is shown that mass transfer is not zero even in isothermal systems. Solubility data are presented for Ni, Cr, and Fe in several liquid metals at 600°C. Mutual solubility effects are discussed, with Fe and Cr in liquid Bi during the corrosion of a type 410 steel crucible as an example. (D.L.C.)

**27887** (NASA-SP-41(p.27-33)) CHEMICAL CORROSION PROCESSES. Leo F. Epstein (General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.).

The effects of impurities on the corrosion of some steels by Na are discussed: oxygen, Zr, Ca, nitrogen, and carbon. The possible role of compounds with limited stability in corrosion processes is discussed with oxygen effects on Fe corrosion by liquid Na as an example. Some comparisons with aqueous systems are made. The differences between corrosion of Fe by Hg and that by Na are discussed. The inhibition of Hg corrosion by Ti is given as an example of solution control by chemical processes. (D.L.C.)

**27888** (NASA-SP-41(p.35-43)) MECHANISMS IN LIQUID-PHASE CORROSION. A. DIFFUSION CONTROLLED. Charles F. Bonilla (Columbia Univ., New York).

Corrosion processes which are diffusion-controlled are treated theoretically. Diffusivity is generally calculated from the Stokes-Einstein formula, and the mass transfer coefficient can then be obtained therefrom. Mass transfer correlations can also be obtained from heat transfer correlations. Finally, the prediction of the rate and extent of the corrosion is considered. (D.L.C.)

**27889** (NASA-SP-41(p.45-7)) MECHANISMS IN LIQUID-PHASE CORROSION. B. SOLUTION CONTROLLED. Leo F. Epstein (General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.).

Quantitative relations for corrosion processes in liquid metals are derived which are applicable to both the diffusion- and solution-controlled processes. The case of a thermal gradient is considered, and an equation is developed for the corrosion rate in a hot-cold loop. The effects of oxygen on the corrosive effects of Na are discussed with particular reference to Fe. (D.L.C.)

**27890** (NASA-SP-41(p.49-59)) EFFECTS OF IMPURITIES. A. OXYGEN. B. NITROGEN AND HYDROGEN. John R. Weeks (Brookhaven National Lab., Upton, N. Y.).

A mechanism for oxygen-catalyzed mass transfer in liquid alkali metals is proposed. The predicted first order dependence was experimentally confirmed. The exchange thermodynamics of oxygen are discussed, and free energies were derived for oxygen in liquid Na, Li, K, and solid Ti and compared with the free energies of formation of several metal oxides. The effects of adsorption and spinel formation on the corrosion rates are considered. Finally, the effects of nitrogen and hydrogen impurities in liquid alkali metal corrosion are considered briefly. (D.L.C.)

**27891** (NASA-SP-41(p.61-5)) EFFECTS OF IMPURITIES. C. CARBON. Leo F. Epstein (General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.).

It is believed that the upper limit of materials in high-temperature service in Na is set by the behavior of C. Austenitic stainless steels remove C from Na and in consequence are transformed to the ferrite phase, while ferritic alloys are decarburized by hot Na, with resulting loss of mechanical strength. The difficulties in the wet and dry combustion methods in the analysis of Na for C are discussed. It is concluded that the nature and reactions of C in alkali metals are still unknown. (D.L.C.)

**27892** (NASA-SP-41(p.67-71)) EFFECTS OF IMPURITIES. D. INHIBITORS AND ACCELERATORS. Leo F. Epstein (General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.).

The dissolution of Ti and Zr in liquid Hg, Bi, and Pb results in the inhibition of corrosion of ferrous alloys. The mechanism of this inhibition is the formation of nitride and carbide films (ZrN and ZrC). The inhibiting effect of Zr in Bi may be prolonged by maintaining the Bi in a $NH_3$ atmosphere. The acceleration of corrosion processes in alkali metals by oxygen is discussed. No inhibitor with an effect in alkali metals similar to that of Ti or Zr in Hg has been found, although several substances function as getters in removing oxygen from alkali metals. (D.L.C.)

**27893** (NASA-SP-41(p.73-4)) HETEROMETALLIC PHENOMENA. John R. Weeks (Brookhaven National Lab., Upton, N. Y.).

An example of problems arising from heterometallic phenomena in liquid metal systems is the migration of Ni from a Ni container through Na to a Mo surface at 1000°C. A layer of MoNi is formed on the Mo surface. The best

way to minimize such problems is to avoid mixing alloys in a liquid metal system unless the metallic constituents of all alloys are insoluble and the activities of all nonmetallics (O, N, C, H) are equalized in all alloys by gettering. (D.L.C.)

**27894** (NASA-SP-41(p.75-81)) NONMETALLIC SOLIDS. A. CERAMICS (THERMODYNAMICS). B. GRAPHITE. Leo F. Epstein (General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.).

The resistance to attack by liquid alkali metals is discussed for several oxidic ceramics. The disastrous effects of silica and other impurities are described for $ZrO_2$ and $Al_2O_3$. The behavior of glasses and some of the newer glasses is considered. The behavior of graphite in liquid sodium and other metallic fluids is also described. Its resistance to Na depends largely on the methods of preparation and closing up the pores. Impurities also have a bad effect on the resistance. Carbides are considered briefly. (D.L.C.)

**27895** (NASA-SP-41(p.83-6)) VAPOR PHASE PHENOMENA. Leo F. Epstein (General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.).

The corrosion phenomena that takes place in the presence of metallic vapors at high temperatures are described. The corrosion due to pure vapors is rather small; most of the observed corrosion is actually due to liquid condensed from the vapor and to carryover of liquid droplets with the vapor. A mechanism for the latter effect is suggested. It is emphasized that, in studies of vapor phase corrosion, boiling instabilities and liquid carryover must be minimized. (D.L.C.)

**27896** (NASA-SP-41(p.87-9)) TWO-PHASE MECHANISMS. John R. Weeks (Brookhaven National Lab., Upton, N. Y.).

Corrosion processes in a boiling loop are described. Slugging or bumping may cause corrosion in the superheater. Materials for use in dry vapor must meet the same requirements as for liquid metal use. The corrosion at the liquid-vapor interface is discussed. (D.L.C.)

**27897** (NASA-SP-41(p.91-5)) SPECIAL TOPICS. A. DOWNSTREAM EFFECT. Leo F. Epstein (General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.).

In the Sodium Mass Transfer loop experiments, the downstream effect was observed. That is, regions of considerable length which were at the same temperature occurred in which the corrosion rate was highest near the beginning of the constant-temperature zone and decreased downstream from this point. Approximate and exact equations were derived for the corrosion rate at a point downstream from the beginning of the zone. The exact equation gave the best agreement with the observations. (D.L.C.)

**27898** (NASA-SP-41(p.97-9)) SPECIAL TOPICS. B. PHYSICAL PROPERTIES (EMBRITTLEMENT). John R. Weeks (Brookhaven National Lab., Upton, N. Y.).

Of the possible liquid-metal embrittlement of container materials, only the stress-embrittlement of AISI 4130 wetted by Li has been observed. The embrittlement mechanism is described and shown to be related to properties at the liquid-solid interface. Strongly adsorbed liquid atoms reduce the interfacial surface energy and hence reduce the stress required to separate atoms of the solid metal. (D.L.C.)

**27899** (NASA-SP-41(p.109-25)) SURFACE ENERGY PHENOMENA AND CORROSION. Robert J. Good (General Dynamics/Astronautics, San Diego, Calif.).

Equations are derived for the free energy of adhesion between two substances and for the interfacial energy. Application is made of the theory to stress-corrosion cracking and to grain boundary grooving and penetration in solution-controlled corrosion in binary liquid metal-solid metal systems. The agreement between theory and experiment is qualitative. The effects of oxygen and other impurities and the corrosion of alloys are considered. (D.L.C.)

**27900** (NASA-SP-41(p.129-86)) COMPATIBILITY TESTS WITH ALKALI METALS. A. CAPSULE TESTS. (National Aeronautics and Space Administration, Washington, D. C.).

Results are presented of 8 questionnaires filled out by participating companies on capsule test programs. The information that is given include test purpose, fluid metal being studied, alloys being tested, capsule dimensions, variables, fluid flow rate, control, measurement, summary of results, etc. (D.L.C.)

**27901** (NASA-SP-41(p.187-215)) COMPATIBILITY TESTS WITH ALKALI METALS. B. LOOP TESTS. (National Aeronautics and Space Administration, Washington, D. C.).

Six questionnaires were filled out on liquid-metal corrosion loops. The results reported include fluid metal being studied, loop type and size, containment alloys, test specimens, loop operation, flow, summary of results, etc. (D.L.C.)

**27902** (NASA-SP-41(p.217-51)) COMPATIBILITY TESTS WITH ALKALI METALS. C. MISCELLANEOUS TESTS. (National Aeronautics and Space Administration, Washington, D. C.).

Results are presented of 9 questionnaires filled out on test programs on liquid-metal corrosion. Information that is given include fluid metal being tested, test specimens, variables, charging, control, measurement, summary of results, etc. (D.L.C.)

**27903** (NASA-SP-41(p.307-12)) PROBLEMS RELATED TO COMPATIBILITY TESTING. B. ENVIRONMENT (OXYGEN "PUMPING EFFICIENCY" OF REFRACTORY METALS). Charles A. Barrett and Louis Rosenblum (National Aeronautics and Space Administration. Lewis Research Center, Cleveland).

An investigation was conducted on the contamination of Nb−1 Zr by oxygen at elevated temperatures in vacuum environments. Weight gains were measured for Nb−1 Zr specimens which were exposed at 980 and 1100°C to oxygen partial pressures from $10^{-5}$ to $10^{-7}$ torr over times up to 236 hr. No surface oxide layer was detected at pressures less than $10^{-5}$ torr, and a crossover from oxygen flux control to diffusion rate control probably occurred at $2.5 \times 10^{-5}$ torr. The pumping efficiency or sticking probability $\epsilon$ of Nb−1 Zr for oxygen was calculated to be 0.02 to 0.03 over the temperature and pressure ranges. (D.L.C.)

**27904** (ORNL-TM-14) INVESTIGATION OF THE EFFECTS OF WET, CHLORIDE-BEARING, THERMAL INSULATION ON AUSTENITIC STEEL PIPE. L. D. Schaffer (Oak Ridge National Lab., Tenn.) and J. A. Klapper (Ebasco Services, Inc., New York). Nov. 1, 1961. Contract W-7405-eng-26. 183p.

In the latter phases of construction of the nuclear-powered merchant ship, the NS Savannah, pressurization tests of the primary system were begun. After the primary system was hydrostatically tested, the piping was insulated so that the temperature of the system could be raised for the hot-flushing operation. Since the system was still under inspection for leak tightness, all joints and areas of potential leaks were left uninsulated. Because the insulating

operation was not complete, the insulation had not been waterproofed. In the course of the hot-flushing operation, several leaks developed in the primary system, including a valve gasket failure. As a result of these events, the insulation was wet with high-purity water in several locations within the reactor containment compartment. Since it was known that the thermal insulation applied to the primary system piping contained chlorides and that the primary system had been thermally cycled several times after the insulation had been wet, an investigation was initiated to determine whether the system had been damaged. It was found that the proper conditions existed for chloride stress-corrosion cracking of the austenitic stainless steel in the primary system. Laboratory investigation of a sample of pipe removed from the primary system indicated that chloride stress-corrosion cracking had begun but that the reaction had been interrupted before serious damage occurred. Therefore, the insulation on the NS Savannah primary system was removed and the underlying piping surfaces were inspected. Indications of surface defects were removed and the piping surfaces were cleaned and re-insulated with an asbestos-type material containing 20% $Na_2SiO_3$. (auth)

**27905** (WCAP-3730) INTERACTIONS BETWEEN STAINLESS STEEL CORROSION PRODUCTS AND BORIC ACID SOLUTIONS. W. D. Fletcher (Westinghouse Electric Corp. Atomic Power Div., Pittsburgh). Mar. 1964. Contract AT(30-1)-3064. 106p.

A study of the interaction of stainless steel corrosion products with boric acid solutions is described, having pertinence to the operation of nuclear power reactors with chemical shim. Data are presented as obtained from tests of synthetic corrosion product oxides with boric acid solutions at normal and elevated temperature, from both out-of-pile and in-pile studies. The equilibrium adsorption of borate by the synthetic oxides was determined, and the kinetics of borate adsorption and desorption are illustrated. Analytical methods for the determination of borate adsorption on the oxides are presented. It is concluded from this work that there is no evidence for irreversible borate incorporation by the oxides at any conditions evaluated. (auth)

**27906** THE EFFECT OF VISIBLE LIGHT ON THE KINETICS OF THE OXIDATION OF THE 0001 SURFACE OF GRAPHITE IN AIR AT 620°C. Francois-Michel Lang and Pierre Magnier (CEA, Saclay, France). Compt. Rend., 258: 4499-4501(May 4, 1964). (In French)

Regions of the surface that were illuminated showed considerably less microroughness than unilluminated regions. Illumination of the rougher region tended to polish it. Apparently, light inhibits the oxidation. (D.C.W.)

**27907** OBSERVATIONS ON THE PREPARATION OF SHEET ALLOYS OF ZIRCONIUM FOR CORROSION TESTS IN CARBON DIOXIDE. R. Syre, J. Bonmarin, and A. Saulnier (Centre de Recherches Metallurgiques de la Compagnie Pechiney, Chambery, France). Corrosion Anti-Corrosion, 12: 43-50(Feb.-Mar. 1964). (In French)

Preparation of small alloy plates is described. Different thermal and surface treatments, possibly having an interesting influence on corrosion in carbon dioxide, are briefly discussed. A micrographic study bearing on the examination of several typical textures of zirconium alloys is presented. Particular attention is given to the epitaxial oxide film, whose observation in the electron microscope by the method of thin films could be the point of departure for a productive examination technique. (tr-auth)

**27908** PARABOLIC GROWTH LAW FOR COHERENT OXIDES. A. T. Fromhold, Jr. (Sandia Lab., Albuquerque, N. Mex.). J. Chem. Phys., 41: 509-?(July 15, 1964).

The Wagner derivation of the parabolic growth law is shown to be inconclusive, since the rate constant can be a function of film thickness. The additional criterion to be met is that the dependence of concentrations C(x,L) on position x and film thickness L(t) be a function of x/L(t) only. This can be examined for any particular case by solving the appropriate diffusion equation and applying the proper boundary conditions. The condition that C(x,L) be a function of x/L(t) for parabolic growth is in accordance with the results of previous work showing that surface charge due to two diffusing species enhances the parabolic rate constant but space charge causes deviations from the parabolic law. The functional form of C(x,L) is examined further by solving the diffusion equation for the general cases in which mobilities $\mu$ vary arbitrarily with temperature and concentration. The parabolic law with modified rate constants is shown to be valid for these general cases, unless the values of $|\mu C|$ for the two oppositely charged species do not differ by more than an order of magnitude and the mobilities depend strongly on several powers of the concentration. (auth)

**27909** FUEL CLADDING CORROSION TESTING IN SIMULATED SUPERHEAT REACTOR ENVIRONMENT, PHASE V: GENERAL CORROSION OF INCOLOY-800. W. L. Pearl, E. G. Brush, G. G. Gaul, and G. P. Wozadlo (General Electric Co., Pleasanton, Calif.). Trans. Am. Nucl. Soc., 7: 118(June 1964).

**27910** THE INTERGRANULAR CORROSION OF STAINLESS STEEL CLADDING IN WATER REACTOR ENVIRONMENTS. T. J. Pashos, W. H. Arlt, C. J. Baroch, and H. E. Williamson (General Electric Co., San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 119(June 1964).

**27911** STRESS CORROSION OF ZIRCALOY-4. K. C. Thomas and R. J. Allio (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 121-2(June 1964).

**27912** HIGH-TEMPERATURE OXIDATION RESISTANCE OF THE BERYLLIDES. R. M. Paine, A. J. Stonehouse, and W. W. Beaver (Brush Beryllium Co., Cleveland). Houston, Tex., National Association of Corrosion Engineers, 1964, Preprint 8. 20p. (CONF-492-4)

From National Association of Corrosion Engineers, Chicago, Mar. 1964.

A study was made on the compounds of Be with the transition elements for potential as high-temperature materials in aerospace applications. Beryllides from 15 binary and 3 ternary systems were examined for oxidation resistance. For the compounds that were found to possess high-temperature oxidation resistance, an attempt was made to ascertain the upper temperature limit (2300°F and above) of useful oxidation resistance in each case. It was concluded that within a binary system the compounds containing the greater proportion of Be are the more oxidation-resistant. The most notable exceptions to this rule are $CrBe_{12}$ and $HfBe_{13}$. (P.C.H.)

**27913** KINETICS OF CORROSION IN A TWO-PHASE MERCURY SYSTEM. J. F. Nejedlik and E. J. Vargo (Thompson Ramo Wooldridge Inc., Cleveland). 30p. (CONF-492-3)

From National Association of Corrosion Engineers, Chicago, Mar. 1964.

The kinetics of mercury corrosion of various conventional materials of construction were studied in glass reflux type capsules with two-phase mercury at temperatures from 600 to 1000°F. These studies showed that although corrosion may proceed initially at a linear rate, steady-state corrosion is essentially diffusion rate controlled for metals which develop a corrosion layer barrier. Penetra-

tion and weight loss plots are presented for representative alloys. Arrhenius type plots of parabolic corrosion rate constants show essentially linear behavior with temperature for a given material. These results were substantiated in thermal convection two-phase natural circulation loop tests. (auth)

**27914** EFFECT OF IMPURITIES IN SOME REFRACTORY METAL–ALKALI METAL SYSTEMS. J. R. Distefano and A. P. Litman (Oak Ridge National Lab., Tenn.). Houston, Tex., National Association of Corrosion Engineers, 1964, Preprint No. 42, 7p. (CONF-492-5)

From National Association of Corrosion Engineers, Chicago, Mar. 1964.

Studies were made to examine the role of contaminants in refractory metals on their corrosion behavior in Li. In addition, an evaluation was made to determine the redistribution of O in other refractory metal–alkali metal systems in the absence of metallographically observable corrosion effects. Results show that the presence of N in Li greatly influences the solubility of some of the refractory metals. Experiments conducted at relatively low temperatures also indicated that O in Na has a detrimental effect on the corrosion resistance of Nb and Ta. Data are presented to compare calculated values of distribution coefficients with experimental values obtained from studies conducted on Nb–O–Li, Nb–O–K, and Zr–O–K systems. Experiments are described that show that there is a strong temperature effect on O transfer in the Nb–O–K system. The ramifications of O redistribution on the operation of an engineering system are also discussed. (P.C.H.)

## Fabrication

**27915** (KAPL-2000-21(p.V.1-20)) BRAZING CHARACTERISTICS AND JOINT STRENGTH OF BRAZING ALLOYS FOR REACTOR APPLICATIONS. C. Schenk, Jr., and J. F. Bollinger (Knolls Atomic Power Lab., Schenectady, N. Y.).

This program was initiated to study the effect of brazing variables on the quality of Ni–Cr–Fe Alloy 600 brazed joints. A group of promising brazing alloys suitable for nuclear applications was investigated to (1) evaluate the effect of time and temperature on alloy flow and base metal erosion, (2) determine the joint design limitations of these alloys, (3) determine their mechanical properties, and (4) evaluate the adequacy of radiography as a quality control measure. For in-core applications, the investigation compared the brazing characteristics of four nickel-base alloys—General Electric J8100B and J8900, Wall Colmonoy Nicrobraz 30, and Coast Metals NP. The Ni–Ge–Cr–Pd–Cu (J8900) alloy exhibited the best flow and mechanical properties of the nickel-base alloys. The optimum joint clearance for this alloy is 0.001 to 0.003 in. For low-flux applications, the study included Handy and Harman's gold-base alloys designated as Premabraze 130, 403, and 409. Premabraze 130, a gold–nickel eutectic alloy, proved to be the superior gold-base alloy. The optimum joint clearance for this alloy is 0.001 to 0.003 in. Alloy 600 will not be excessively eroded by these brazing alloys if the brazing conditions are controlled. (auth)

**27916** (KAPL-2000-21(p.VIII.1-7)) THE EVALUATION OF A VICKERS WELDING POWER SOURCE FOR AUTOMATIC SEAL WELDING APPLICATIONS. H. MacLaren and R. E. Beach (Knolls Atomic Power Lab., Schenectady, N. Y.).

Accurate control of parameters during the automatic welding of an omega seal is necessary if the desired weld contour is to be maintained. Although fixed parameters such as arc gap, electrode shape, and travel speed can be easily controlled, variations in line voltage can measurably change the welding amperage unless suitable control circuitry is provided. The Westinghouse RA welder, a rectifier-type power supply widely used for automatic seal welding applications, was originally designed for manual metal arc welding. Therefore, modifications must be made to ensure accurate control of amperage during a seal weld cycle. These modifications consist of using a motor to move the screw-fed core, and using either auxiliary line voltage regulators or amperage sensing circuits to compensate for changes in line voltage. Neither of these methods has been considered satisfactory since auxiliary line voltage regulation equipment is too massive for shipboard operation, and existing amperage controls have not been capable of correcting rapidly enough for extreme surges in line voltage. The Vickers Electric Corporation manufactures a d-c welding power source which incorporates line voltage control through a magnetic amplifier circuit. Tests conducted to evaluate the response of a 300-amp Vickers "Controlarc" power source to line voltage fluctuations are discussed. Detailed data are presented, and recommendations are made regarding the advantages and potential applications of the power source. (auth)

**27917** (LA-2485) FABRICATION AND EVALUATION OF POWDER-ROLLED TUNGSTEN–URANIUM DIOXIDE DISPERSIONS. T. J. Ready, W. V. Green, and H. D. Lewis (Los Alamos Scientific Lab., N. Mex.). Apr. 6, 1964. Contract W-7405-eng-36. 45p.

Investigation of the many interrelated variables affecting the precision powder-rolling of a refractory metal fuel element material has led to the successful preparation of tungsten-45 vol % $UO_2$ dispersion-alloy sheets. This report summarizes the conditions necessary for the production of the alloy strip and describes the details of the steps involved in the successful hot-rolling of specimens taken from the powder-rolled strip. Preliminary creep-rupture test data are presented, and the strength of the alloy is compared to that of commercial tungsten rod. (auth)

**27918** (ML-TDR-64-108) DEVELOPMENT OF IMPROVED FABRICATION METHODS, PROCESSES, AND TECHNIQUES FOR PRODUCING TYPICAL AIRCRAFT SHAPES FROM BERYLLIUM. Final Technical Documentary Report. R. G. Jenkins, J. M. Siergiej, A. K. Wolff, and J. L. Klein (Nuclear Metals. Div. of Textron Inc., West Concord, Mass.). Mar. 2, 1964. Contract AF33 (657)-8783. 132p.

A basic procedure was developed for warm drawing long lengths of a complex beryllium structural shape to accurate dimensions. The starting shape was a U-channel extrusion having a $1\frac{1}{2}$ inch wide web, 1 inch high flanges, and a thickness of flange and web of 60 to 100 mils. Draw reductions of up to 16 percent were obtained in a single pass, and reductions up to 39 percent were obtained by multiple draws. The maximum length drawn was approximately 10 feet. Large increases in longitudinal and transverse strength properties at room temperature and at –100°F are obtained by drawing at 800°F; on the average, the increase in yield strength is approximately 2500 psi per one percent drawing reduction. However, drawing reduces the ductility; for example, the longitudinal room temperature ductility of approximately 6 percent is reduced to approximately 2 percent by a 14 percent draw reduction. Annealing after drawing reduces the strength but does not restore the ductility. Both strength and ductility are higher in the longitudinal direction than the transverse direction. The preferred orientation of the basal planes caused by extrusion is not changed appreciably by drawing. (auth)

**27919** (NMI-1131) ATOMIC POWER DEVELOPMENT ASSOCIATES PROGRESS REPORT [ON CASTING FUEL ELEMENTS], DECEMBER 1, 1954–JANUARY 1, 1955. R. Evans, L. Minnick, A. Boltax, and E. Rapperport (Nuclear Metals, Inc., Cambridge, Mass.). Feb. 24, 1955. Contract AT(30-1)-1565. 27p.

Work during this period has consisted mainly of extending the present casting techniques for the U–Cr alloy toward the final element size. Several 24-in. long castings of U–Cr were made utilizing spiral wire and washer-type spacers in an 85-tube cross section. Top gates and tight fitting molds were used on all castings made during this period. Extensive dimensional tolerance data has been taken on these castings and shows that the ligament tolerance of 0.030 ± 0.003-in. is being held in 80 to 90% of the cross section. A second pair of flat plates was cast 0.040-in. thick, 3.5-in. wide, and 28-in. long in graphite using a technique similar to that reported last month. Two 6-in. long U–Zr radiator castings were made for pouring condition and bond examination. It has been possible to force a tube away from the metallurgical bond area but no physical strength data is available. The investigation of the bond structure is being carried on with each specimen cast. Parts and components of the continuous casting device are finished and under construction. (auth)

**27920** (NMI-1123) ATOMIC POWER DEVELOPMENT ASSOCIATES PROGRESS REPORT [ON CASTING FUEL ELEMENTS], OCTOBER 1–NOVEMBER 1, 1954. R. O. Evans, A. Boltax, and E. J. Rapperport (Nuclear Metals, Inc., Cambridge, Mass.). Dec. 15, 1954. Contract AT(30-1)-1565. 21p.

The effort to maintain a tube spacing tolerance was continued. Design and construction of the mold and tube assembly was completed and the uranium–chromium casting made successfully. Results show that about 70% of the tubes remained within tolerance. Equipment for casting future radiators and plates was designed and construction started. Castings of uranium–zirconium around zirconium tubes were made, examined, and compared with other work. (auth)

**27921** (NMI-1129) ATOMIC POWER DEVELOPMENT ASSOCIATES PROGRESS REPORT [ON CASTING FUEL ELEMENTS], NOVEMBER 1–DECEMBER 1, 1954. R. Evans, L. Minnick, A. Boltax, and E. Rapperport (Nuclear Metals, Inc., Cambridge, Mass.). Jan. 10, 1955. Contract AT(30-1)-1565. 17p.

Research on U–Cr castings of a hexagonal, radiator-type element 1.8-in across flats was continued. A 12-in. long element having 85 oxidized tubes was poured. The spacers used were low-carbon iron wire. Dimensional analysis shows that 70–75% of the tubes fall within the tolerance specified. The casting of flat plates for use in an assembled element was successfully completed. A pair of plates .040-in. thick, 3.5-in. wide, and 28-in. long was cast in graphite at a low temperature. Bonded radiators were cast using uranium-1.5% zirconium against zirconium tubes. The castings were made with an 85-tube bundle 3-in. high in a cylindrical mold. (auth)

**27922** (ORNL-3632) PROCEDURES FOR FABRICATING ALUMINUM-BASE ATR FUEL ELEMENTS. R. J. Beaver, G. M. Adamson, and P. Patriarca, comps. (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 89p.

One of the major objectives in the development of the curved plate, aluminum-base fuel element for the 250-Mw Advanced Test Reactor was to determine whether relatively inexpensive fabrication techniques that are amenable to commercial manufacturing could be utilized in making this rather unique fuel element. The design of this component departs from the customary research reactor fuel element because of the high performance requirements to achieve neutron fluxes in the order of $2 \times 10^{15}$ neutrons/cm$^2$ sec. The reactor fuel core is 48 in. long and contains 40 fuel elements in a serpentine fuel core arrangement. Nine high-flux regions are provided in the reactor. Because of this serpentine arrangement, each fuel element in cross section is wedge shaped, and each of the 19 plates in the fuel element has its own specific radius of curvature. The fuel investment in each element is rather high (750-g $^{235}$U) and necessitates the use of boron as a burnable poison to control the reactivity lifetime. Because of these considerations, $U_3O_8$ and $B_4C$, respectively, were selected as the fuel and burnable poison compounds. Each plate contains 34 wt % $U_3O_8$ and 0.2 wt % $B_4C$. This report describes in detail the fabrication techniques that were used successfully to make several fuel elements. Conventional powder metallurgical dry-blending techniques produced fuel compacts with homogeneous mixes of the $U_3O_8$, $B_4C$, and aluminum. More than 95% of the plates clad with type 6061 aluminum by hot roll bonding met specified dimensions. A modified marforming process shaped plates with acceptable radii of curvature. Extraordinarily close control of the spacings was achieved by assembling the plates between two grooved type 6061 aluminum side pieces and mechanically joining by use of roll-swaging techniques. (auth)

**27923** (WADD-TR-61-72(Vol.XXXII)) RESEARCH AND DEVELOPMENT ON ADVANCED GRAPHITE MATERIALS. VOLUME XXXII. STUDIES OF BINDER SYSTEMS FOR GRAPHITE. T. Edstrom, I. C. Lewis, R. L. Racicot, and C. F. Stout (National Carbon Co. Advanced Materials Lab., Lawrenceburg, Tenn.). Oct. 1963. Contract AF33(616)-6915. 49p.

Binder systems were investigated with respect to their thermosetting characteristics both to replace pitch-sulfur combinations presently used in the pressure-curing process and to provide binders for development of new graphite grades. The binder systems included: (a) prepolymerized furfural-alcohol resin; (b) pitch, furfural, furfuryl-alcohol combinations; (c) pitch with a ferric chloride catalyst; and (d) pitch with oxidizers such as inorganic persulfates, chlorates, and oxides. Acenaphthylene pitch, a new binder, was investigated with regard to thermosetting properties when used in the pressure-curing process. These binder systems were used in the fabrication of graphite articles and property determinations were made on the finished graphites. The binder modifications or systems investigated have produced no outstanding advantages over the pitch-sulfur system for use in the pressure-curing process. The most promising of the new systems was pitch combined with oxidizing agents other than sulfur, which produced a thermosetting binder of high coking value and which was comparable to the pitch-sulfur binder in other properties. (auth)

**27924** (WANL-PR-(N)-004) DEVELOPMENT OF HIGH-STRENGTH COLUMBIUM AND TANTALUM ALLOY TUBING. Final Technical Report, December 1, 1962–February 29, 1964. R. W. Buckman, Jr., and J. L. Godshall (Westinghouse Electric Corp. Astronuclear Lab., Pittsburgh). May 1, 1964. Contract AT(30-1)-3108. 79p.

Two high strength refractory metal alloys, B-66 (Cb–5Mo–5V–1Zr) and T-111 (Ta–8W–2Hf), were processed to tubing from extruded tube blanks. Three sizes of tubing, 0.500 inch OD × 0.062 inch wall, 0.375 inch OD × 0.062 inch wall, and 0.250 inch OD × 0.015 inch wall were produced in

lengths of 20 to 94 inches. The yield of finished tubing was 20.3% of the starting extrusion billet weight for B-66, and 35.9% for T-111. A sequence of hot extrusion to tube blanks, tube rocking to redraw stock, and tube drawing was utilized. The T-111 tube blanks were processed at room temperature, while the B-66 was generally processed at 400 to 600°F. However, experimental work indicated that B-66 can be worked at room temperature if the proper microstructure is developed and satisfactory lubrication can be maintained. Chemical analysis of finished tubing showed no detectable increase in interstitial level during processing, except in the 0.250 inch OD × 0.015 inch wall tubing were an increase in oxygen level was observed. Room temperature tensile tests on annealed finished tubing gave results comparable to sheet properties of the two alloys. (auth)

**27925** (EURAEC-989) PREPARATION OF $UO_2$ POWDERS OF HIGH BULK DENSITY BY MELTING AND GRINDING AND THEIR PROCESSING INTO FUEL ELEMENTS. Quarterly Report No. 13, July 1–September 30, 1963. W. Duerrschnabel, W. Hoppe, B. Liebmann, O. Neumann, P. Saalfeld, and L. Schikarski (Nuklear-Chemie und-Metallurgie G.m.b.H., Wolfgang bei Hanau am Main, Germany). Work Performed under United States–Euratom Joint Research and Development Program. Contract 013-63-7/TEED. 69p. (A translation).

$UO_2$ was melted by direct passage of current, and the balance of material of the process was checked. A thorough examination of the compact product revealed that it is satisfactory with respect to its density, stoichiometry, and carbon and nitrogen content. Tests for vibration compacting of powder of melted $UO_2$ revealed that the slight heating of the material resulting from the vibration process has no effect on the oxygen content of the powder. Investigations for the selection of appropriate characteristics for defining the breaking behavior of molten $UO_2$ powders carried out in a model vibration test with a single grain size showed as satisfactory a definition based on the final density after vibration, the amount of adjacent fraction formed and the amount of the formed part of fine (grain diameter <0.06 mm). It follows therefrom that overstoichiometric powders (O/U = 2.04) have better vibration properties than powders of almost stoichiometric composition (O/U = 2.01). The influence that the weight of the stamp and the width of the gap between the latter and the sheath have on the densities and density variations obtained by vibration were examined. The best results are obtained when the stamp weighs 5 kp and in the presence of a gap of 50 μ. Tests with various tube locks were tried with the object to simplify the process when swaging and finishing the elements. (auth)

**27926** TECHNICAL NOTES ON WELDING OF A REACTOR FOR AN ELECTROTHERMAL NUCLEAR PLANT. C. Tissi, G. Popoli, and G. Paris. Arcos (Brussels), No. 149, 17-65(Jan.-Dec. 1961). (In Italian)

A complete description of various processes is given in the fabrication of a Cr–Ni–Mo steel nuclear reactor pressure vessel. Processes described include series arc welding, welding deposition of stainless steel inside the vessel, various nondestructive tests, and tensile, bend, and hardness testing. Mechanical and physical properties of the steels and weldments are reported. (Rev. Metal Lit., 21: No. 5, May 1964)

**27927** WELDING OF COLUMBIUM PRODUCED BY VACUUM-ARC AND ELECTRON-BEAM TECHNIQUES. E. I. Istomin and Yu. P. Humenyuk. Avtomat. Svarka, No. 1, 25-7(1964). (In Russian)

Butt welding of vacuum refined and electron beam refined Nb foils of 1 mm in thickness by argon arc and electron beam welding techniques was investigated. The weldability, porosity, microstructure, hardness, and bend strength of the weldments of both types were studied and selection of optimum welding rates and current was made. (Rev. Metal Lit., 21: No. 5, May 1964)

**27928** DEPOSITION OF TANTALUM FILMS WITH AN OPEN-ENDED VACUUM SYSTEM. J. W. Balde, S. S. Charschan, and J. J. Dineen. Bell System Tech. J., 43: 127-42(Jan. 1964).

The capability of open-ended vacuum depositing equipment was investigated to determine its suitability for depositing thin tantalum nitride films. This was accomplished by measuring the electrical properties of the deposited film and determining the stability of resistors made from the film. (Rev. Metal Lit., 21: No. 5, May 1964)

**27929** THE DIFFERENT METHODS OF SPHEROIDIZING. H. Bildstein (Osterreichische Studiengesellschaft fur Atomenergie GmbH, Vienna). Ber. Deut. Keram. Ges., 41: 108-11(1964). (In German)

Three methods of spheroidizing uranium carbide or mixed carbides of uranium are described. The method of melting by electric arc yields spheroids of high purity and almost free from pores but their maximum diameter is 500 μm. The plasma method gives, with lower melting carbides, spheroids of higher porosity and of greater diameters and can be used for spheroidizing metallic and oxidic materials. The last-named method is particularly suitable for producing spheroids of carbide materials on a large scale. (auth)

**27930** INCIDENCE OF NUCLEAR PURITY RESEARCH ON THE TECHNIQUES OF FABRICATION AND CONTROL IN THE ZIRCONIUM INDUSTRY. COMPARISON WITH TITANIUM. J. Artaud (CEA, France) and J. Aubert. Chim. Anal. (Paris), 46: 77-82(Feb. 1964). (In French)

After a review of the principal properties of Ti and Zr, which cause their utilization in very specialized regions, the characteristics of their fabrication and the quality controls necessary during fabrication are described. The methods used in quality control are optical spectroscopy, x-fluorescence spectrography, activation analysis, and chemical analysis. The effect of these controls on the cost of the product is also examined. (tr-auth)

**27931** ELECTROLYTIC ETCHING AND POLISHING OF TUNGSTEN–RHENIUM ALLOY. V. I. Layner, K. N. Usol'tseva, and V. N. Parusnikov. Izv. Vysshikh Uchebn. Zavedenii, Tsvetn. Met., No. 6, 124-30(1963). (In Russian)

The electrolytic etching and polishing of VR-2 Alloy (80% W and 20% Re) in $NaOH-Na_2WO_4-Na_3PO_4$ electrolyte at 20 to 80°C was investigated. The dependence of surface finish of the polished specimens on composition and temperature of electrolyte, alkalinity, and current density was determined. (Rev. Metal Lit., 21: No. 5, May 1964)

**27932** RANDOM PYROLYTIC CARBON. J. C. Bokros (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Nature, 202: 1004-5(June 6, 1964).

Investigations showed that a completely random pyrolytic C structure can be deposited at 1900°C in a fluidized bed. Material was deposited at 1900°C on graphite disks from 1:40 and 1:10 mixtures of methane in He at atmospheric pressure. The density and apparent crystallite size were calculated for each deposit. Other experiments showed that the orientation depends on deposition temperature, the partial pressure of the hydrocarbon used, and the geometry of the fluidized bed. (P.C.H.)

**27933** ORIGIN AND DEVELOPMENT OF THE CUP AND CONE DEFECT ON DRAWING AND WIRE DRAWING AT ROOM TEMPERATURE. THE CASES OF COPPER, ZIRCALOY 2, FRITTOXAL AND ALMELEC. J. Boghen, C. Leymonie, and J. Herenguel. Rev. Met. (Paris), 60: 1241-8(Dec. 1963). (In French)

The cup and cone defect is produced at the same time under mechanical conditions and structural factors, notably in the presence of brittle constituents or inadequate compactness. An effective remedy in many cases is the use of medium drawing temperatures, for instance for U drawn under a Cu can at 250°C. (P.C.H.)

**27934** DENSITY CHANGES ON ANNEALING COLD-WORKED MOLYBDENUM. Harry W. Antes (Univ. of Pennsylvania, Philadelphia and Frankford Arsenal, Philadelphia). Trans. Met. Soc. AIME, 230: 550-4(Apr. 1964).

Density changes that occurred on annealing cold-worked polycrystalline Mo, over the temperature range of 870 to 1630°C, were determined. Increases in density were observed for recovery and the beginning of recrystallization. An initial decrease in density was observed during recrystallization. A second decrease in density was observed after recrystallization was completed, as the microstructure changed from columnar grains to equiaxed grains. Both decreases in density were associated with an increase in grain boundary area to volume ratio. The second decrease in density was observed in the annealing range that immediately precedes secondary recrystallization as previously reported. (auth)

**27935** ON THE LIBERATION OF RADON BY THE MECHANICAL WORKING OF A NICKEL SURFACE BOMBARDED WITH $^{222}Rn$ IONS. G. Heinicke, C. Jech, and K. Winkler (Inst. for Physical Chemistry, Berlin and Inst. for Physical Chemistry, Prague). Z. Physik. Chem. (Leipzig), 225: 161-7(1964). (In German)

In the mechanical working of nickel surfaces with rich corundum grains changes appeared in the kind of attack, which led to thermodynamically unstable states. Due to this, moreover, the loosening work on the crystal surface was decreased. These processes were investigated by the method of radioactive surface labeling developed by Jech. The freeing of radon observed in the working in its characteristic pattern is analogous to the chemical processes resulting from impact working. It is shown that the processes depend decisively on the intensity of the working. (tr-auth)

**27936** BERYLLIUM CHIP PRESS DIE (Engineering Materials). (Union Carbide Corp. Nuclear Div. Y-12 Plant, Oak Ridge, Tenn.). (CAPE-1118)

This package contains 1 drawing. For a listing of this title, see the Engineering Materials List (TID-4100). The Be chip press die is used to prepare Be samples used in determining microgram quantities of chloride in Be metal powder utilizing x-ray emission spectrometry. Ten grams of clean Be chips are pressed at 61 tons for ~10 sec. Clean gloves should be worn so that the metal is not contaminated. The cylindrical protective sleeve is 4.5 in. in dia, 3.125 in. high, and 0.25 in. thick. The shrink ring is 4 in. in dia, 3.125 in. high, and 1 in. thick. The die core is 1.95 in. OD, 1.45 in. ID, and 3.125 in. high. The forming pin is 2 in. high and 1.5 in. in dia. The load block is 4 in. in dia and 1.5 in. thick. Specifications for fabricating parts are included on the drawing. (F.S.)

**27937** METALLURGICAL BONDING OF DISSIMILAR METALS BY CO-EXTRUSION. Paul Lowenstein and Wilson B. Tuffin (Nuclear Metals, Inc., Concord, Mass.). Metals Park, Ohio, American Society for Metals, 1964, Technical Report No. W4 3.2, 17p. $3.00. (CONF-540-2)

From American Society for Metals, Western Metal and Tool Conference, Los Angeles, Mar. 1964.

The co-extrusion process lends itself to the production of high quality metallurgically bonded shapes of metals. Mechanical aspects and metallurgical aspects of bonding are described. The importance of bond layer thickness, when brittle compounds form, is discussed. Specific illustrations of applications of the process to rods, shapes, tubes, and tubular transition joints, are given. (auth)

**27938** BRAZING REFRACTORY METALS. M. M. Schwartz (Martin Co., [Baltimore]). Metals Park, Ohio, American Society for Metals, 1964, Technical Report No. W4 3.3, 32p. $3.00. (CONF-540-1)

From American Society for Metals, Western Metal and Tool Conference, Los Angeles, Mar. 1964.

Significant recent advances in the development of brazing alloys, tooling, equipment, parting agents, and fabrication techniques for the first and second generation refractory metal alloys are appraised. Future applications for these materials are discussed and significant testing data on which future design requirements will be based are included. Special attention is given to Mo and Nb alloys that are more readily available and fabricable. The Nb alloys include: D-36 (Nb–10Ti–5Zr), D-43 (Nb–10W–1Zr–0.1C), and Nb752 (Nb–10W–3Zr). (P.C.H.)

**27939** FUEL ELEMENTS FOR NUCLEAR REACTORS. Stephan George Bauer (to Rolls-Royce Ltd.). British Patent 960,854. June 17, 1964. Filed Oct. 13, 1961.

A method is given for bonding $UO_2$, UC, or UN to a can for use as a fuel element. The method comprises coating the internal wall of a stainless steel sheath with Ni or a Ni–P alloy, coating a fissile mass of $UO_2$, UC, or UN with Ni by vapor deposition, encasing the fissile mass in the sheath, creating a high vacuum within the sheath, and heating the encased mass to 800 to 1050°C to effect a diffusion bond or braze between the coatings of the sheath and fissile mass. The fuel element is preferably formed with a wedge-shaped cross section, and a plurality of such fuel elements may be disposed in an annular space to constitute a fuel element assembly. (D.L.C.)

**27940** APPARATUS FOR FORMING TUBULAR ARTICLES WITH SPIRAL FINS. Robert Cazeneuve, Jean Herenguel, and Michel Scheidecker (to Commissariat a l'Energie Atomique). British Patent 961,011. June 17, 1964. Priority date Mar. 21, 1962, France.

An apparatus for forming tubes with spiral fins for use as fuel element sheaths, is designed which acts on tubes already provided with rectilinear longitudinal fins and mounted on a mandrel. The apparatus comprises a housing member with an annular recess in which is located a blade carrier. The blades are located between the fins, and the fins are transformed into spiral fins by rotation of one of the two jaws between which the tube ends are held. A variable spiral pitch may be obtained as well as a constant pitch. (D.L.C.)

**27941** CARBON ELECTRODES OR NEUTRONIC REACTOR CORE BARS AND METHOD AND APPARATUS FOR MAKING SAME. (to Great Lakes Carbon Corp.). British Patent 961,067. June 17, 1964. Priority date Feb. 9, 1961, United States.

A process and extrusion apparatus are described for forming carbonaceous electrodes or bars of rectangular cross section with maximum stability and minimum ra-

diation damage susceptibility. The process comprises extruding a mass of carbon platelets in such a way that the lamellae are disposed parallel and lengthwise of the bar. The extruded bar may then be baked and graphitized. The thermal expansion and other properties of the resulting bar shows the same amount of anisotropy as a graphite single crystal. (D.L.C.)

**27942** METHOD OF PRODUCING CERAMIC FUELS FOR NUCLEAR REACTORS. Ronald George Sowden (to United Kingdom Atomic Energy Authority). U. S. Patent 3,137,742. June 16, 1964. Priority date Sept. 5, 1960, Great Britain.

A relatively simple method is given for producing $UO_2$–$PuO_2$ ceramic fuel pellets with uniform Pu distribution. The method comprises dissolving a Pu salt (preferably plutonyl dinitrate) in an organic solvent (preferably hexone), adding an organic binding agent for $UO_2$ to the solution, adding the solution to $UO_2$ powder to granulate the powder, drying the mixture, and finally compacting and sintering the mixture. The organic binding agent may be polybutyl methacrylate or some other polymer, and a plasticizer such as glycerol or dibutylphthalate may be added to the binding agent. Various modifications of the steps of the method are described. (D.L.C.)

## Properties and Structure

**27943** (AD-426957) EVALUATION OF RMSP TUNGSTEN SHEET. Quarterly Progress Report 2, October 1, 1963–December 31, 1963. F. St. Germain and M. R. Licciardello (Solar. Div. of International Harvester Co., San Diego, Calif.). Jan. 15, 1964. Contract NOw 63-0786d. 49p. (ER-1399-2)

The 0.010-, 0.020-, 0.060-, and 0.100-in.-thick tungsten sheets were evaluated by standard acceptance test methods. Chemical analysis, microstructural evaluation, hardness measurements, bend transition studies, and elevated temperature mechanical property determinations were performed and the results were recorded for the serialized sheet material. The results obtained during acceptance testing indicated that there were differences between individual sheets within each gage lot of sheet material. These differences could be ascribed to prior processing history; however, sufficient data are not available to allow for detailed tracing of each sheet produced. Hot square shearing and hot rotary shearing investigations were conducted on each of the four gages of RMSP tungsten material. Results of the shearing studies showed that successful shearing could be expected by control of temperature of sheet material, type, and condition of tooling used. (auth)

**27944** (AERE-R-4229) MEASUREMENT OF THE REVERSAL TIME AND OF SOME VARIATIONS IN THE ANISOTROPY OF ELECTRODEPOSITED PERMALLOY FILMS. A. B. Clare (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Apr. 1964. 42p.

Thin ferromagnetic films of electrodeposited nickel–iron were examined: the films possess a uniaxial anisotropy. Applied magnetic fields cause the magnetization to rotate away from the axis to a new equilibrium angle inferred from the flux changes. The flux changes were measured as a voltage-time integral by a technique using a sampling unit and a linear diode pump circuit. The results are mainly consistent with the model in which the anisotropy varies in both direction and magnitude. The time required for the magnetization to reverse its direction appears to be longer than in the case of evaporated films. The magnetization reverses incoherently in a manner that can be correlated with the way in which the anisotropy varies. (auth)

**27945** (ASD-TDR-63-585(Vol.II)) MECHANICAL PROPERTIES OF WROUGHT TUNGSTEN. C. A. Drury, R. C. Kay, A. Bennett, and M. J. Albom (Marquardt Corp., Van Nuys, Calif.). Aug. 1963. Contract AF33(616)-7385. 104p. (AD-427128)

Tensile and creep properties to 5000°F were determined for wrought unalloyed tungsten sheet in order to establish design criteria. Three lots of material, prepared in accordance to the same specification, were used. Hardness and tensile values below 2500°F could be correlated for entire lots of material. Correlation was found at strain rate and hold time versus tensile strength properties or elongation values, at certain temperatures. Properties varied with powder lot to such an extent as to affect design parameters. (auth)

**27946** (BBC-120) RESEARCH ON MODIFIED BERYLLIDES AS HIGH-TEMPERATURE NUCLEAR MATERIALS. Summary Technical Report, September 1, 1962–August 31, 1963. R. M. Paine, A. J. Stonehouse, and W. W. Beaver (Brush Beryllium Co., Cleveland). Oct. 15, 1963. Contract AT(33-3)-20. 42p.

Work is described which was aimed at improving the high-temperature properties of modified beryllides (beryllides containing aluminum, silicon, NiAl, etc.) while at the same time maintaining their excellent oxidation resistance at intermediate temperatures. It is shown that the high-temperature strength of aluminum–containing zirconium beryllides can be significantly improved by maintaining aluminum levels such that all of the aluminum is solubilized at these temperatures. Such materials also show excellent high-temperature oxidation resistance. Solubility data for aluminum, silicon, and nickel in $ZrBe_{13}$ and $Zr_2Be_{17}$ are presented. Some additional work with aluminum additions to niobium beryllides is described. (auth)

**27947** (CEA-R-2426) MISE AU POINT D'UNE CHAMBRE UNICAM A HAUTE TEMPERATURE ET APPLICATION A LA DIFFRACTION DE RAYONS X SUR L'URANIUM EN POUDRE. (Development of a High-Temperature UNICAM Camera and Application to X-Ray Diffraction on Powdered Uranium). Jean Laugier and Pierre-Lazare Blum (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucleaires, Grenoble). Apr. 1964. 16p.

A high temperature commercial x-ray camera (UNICAM S150), modified in order to improve some of its performances, is adapted to the uranium powder problem. The strong uranium reactivity for oxygen and silica, the sintering, and the grain growth in $\beta$ phase are avoided. X-ray photographs are thus possible even in the $\gamma$ phase. (auth)

**27948** (CEND-3107-210) BURNABLE POISON ADDITIONS TO $UO_2$. Progress Report, Period Ending March 31, 1964. R. C. Brayer and W. P. Chernock (Combustion Engineering, Inc. Nuclear Div., Windsor, Conn.). Apr. 1964. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(30-1)-3107. 26p. (EURAEC-1071)

Microscopic evaluation of samples containing fused $UO_2$-3 wt % $B_4C$ after heat treatments to two hours from 1600 to 2100°C indicated reaction product particles which were irregularly shaped and partially embedded in the $UO_2$. The reaction products were tentatively identified as $UB_4$ and/or $UB_2$ on the basis of x-ray diffraction analyses.

Re-evaluation of thermodynamic data for a closed system, typical of that encountered in an operating fuel element, reconfirmed previous conclusions that the formation of significant amounts of volatile boron species is improbable. Additional tests to confirm these conclusions are being initiated under conditions in which $UO_2-B_4C$ mixtures are heated to temperatures up to 2300°C in an axial gradient of 10°C/cm with no artificially imposed radial gradient. Other tests are being initiated with the aim of inducing boron migration by removing gaseous reaction products during testing under conditions in which the ratio of radial to axial thermal gradient is approximately 250. An irradiation program is formulated and requests for quotation are issued for irradiation testing of two elements for burnups up to 5000 Mwd/mtu. (auth)

**27949** (COO-1198-165) EFFECT OF Al, Si, Ge AND Sn SOLUTES ON THE ELECTRONIC STRUCTURE OF B.C.C. ALLOYS OF 3d TRANSITION ELEMENTS. Paul A. Beck (Illinois. Univ., Urbana). [1964]. Contract AT (11-1)-1198. 15p.

Electronic specific heat measurements for several bcc binary and ternary alloys of 3d transition elements were made in order to decide whether or not the non-transition element solutes contribute electrons to the 3d-band. The effects of Al on Ti–V, Fe, V–Cr, Cr–Fe, and Fe–Co alloys are discussed in some detail. The results indicate that the effects on the electronic structure (magnetic properties) cannot be explained in terms of filling a more-or-less rigid d-band. (D.L.C.)

**27950** (COO-1198-168) INTERNAL FRICTION STUDIES OF DISLOCATIONS. A. V. Granato (Illinois. Univ., Urbana). [1964]. Contract AT(11-1)-1198. 41p.

A review is given of the type of information concerning mechanical properties of crystals obtainable from internal friction measurements. The methods of measurement, together with their advantages, disadvantages, and limitations are outlined. Results are described within a framework in which defect interactions are considered from the "particle" point of view. A selection of results found by internal friction techniques which are often difficult to obtain by other methods is described. These include recent measurements which have contributed to the understanding of dislocation interactions with point defects and phonons, as well as dislocation distributions in deformed materials. (auth)

**27951** (EURAEC-806) INTERPRETATION AND EVALUATION OF NON-IDEAL GAS RELEASE IN POST-ACTIVATION MEASUREMENTS (RARE-GAS DIFFUSION IN SOLIDS 11). T. Lagerwall and P. Schmeling (Hahn-Meitner-Institut fur Kernforschung, Berlin). Oct. 1963. Work Performed under United States–Euratom Joint Research and Development Program. 50p. (HMI-B-27)

A review of possible causes of the non-ideal gas release kinetics often observed in post-activation diffusion experiments is given. It is pointed out that in the calculation of diffusion coefficients from the corresponding release curves, D-values that may be different by orders of magnitude will come out, depending on different interpretation of the experimental curve. This may contribute to the uncommonly broad scattering of the values of diffusion coefficients found in the literature and shows a deeper insight of the underlying physical processes is needed in order to evaluate the experimental data correctly. On discussing present experimental results, different assumptions regarding the nature of these processes are made, and the consequences for the experimentally observed release patterns are discussed. Recommendations are given for the evaluation of complicated release curves. (auth)

**27952** (EURAEC-926) IN-PILE CORROSION OF NUCLEAR MATERIALS. Quarterly Report No. 7, October 1–December 31, 1963. (Centre d'Étude de l'Énergie Nucléaire, Mol, Belgium). Work Performed under United States–Euratom Joint Research and Development Program. Contract 084-62-3RDB. 22p. (R-2266)

Experimental studies are carried out of the electrochemical characteristics of Pt electrodes in $HNO_3$, KOH, $KHCO_3$, KCl, $H_2O$, and $NH_4NO_3$ solutions, as a function of exposure to reactor irradiation; electrochemical characteristics of Pt electrodes saturated with air, $N_2$, and Ar in $KHCO_3$ solutions as a function of exposure to reactor irradiation; and the effects of reactor irradiation on Zr, Zircaloy-2, Nb, and Ti. (T.F.H.)

**27953** (EURAEC-973) PHYSICAL PROPERTIES OF $UO_2$ SINGLE CRYSTALS. Quarterly Report No. 8, October 1–December 31, 1963. (Centre d'Étude de l'Énergie Nucléaire, Mol, Belgium). Work Performed under United States–Euratom Joint Research and Development Program. Contract 010-63-3/TEEB. 21p. (R-2275)

Single crystals up to 10 g have been grown by using cylinders made by a modified slip-casting technique. The kinetics of the oxidation of $UO_2$ are studied. Two furnaces have been constructed allowing the annealing of the $UO_2$ samples for diffusion and sintering experiments under an oxygen pressure sufficient to maintain original composition during the whole annealing time. Experimental data on the stability of coherent precipitates are compared with the annealing behavior of point defects after fission fragment damage (investigated by electrical conductivity). The thermal conductivity of a prism 8 mm in length has been measured between 4 and 300°K. Up to 100°K no qualitative deviation from the results obtained on sintered polycrystalline material is found. By measuring the electrical conductivity of crystals with varying composition, it has been established that the solubility of oxygen at 300°K is smaller than 2.001. In-pile measurements of the electrical conductivity have been performed; no ionization effects could be detected. The validity of polaron theory is investigated. The wave velocity of longitudinal waves is measured at room temperature by a pulse-echo technique. (auth)

**27954** (GAMD-4904) RESIDUAL STRESSES IN EXTRUDED GRAPHITE TUBES. R. J. Price (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Jan. 10, 1964. Contract AT(04-3)-167. 13p.

Extruded graphite tubes contain a strong crystalline texture which results in highly anisotropic thermal expansion coefficients in the tube wall. This could lead to high residual stresses in material cooled from the heat treatment temperature, and experiments involving cutting a longitudinal slit in a length of tubing and measuring the opening or closure of the gap do indeed reveal the presence of residual tangential stresses. This deflection method gives no details of the stress distribution, and the magnitude of the stress computed depends on arbitrary assumptions made about the stress distribution. A complete analysis of the residual stresses in a tube can be made by the Sachs boring-out technique, where changes of length at the outer surface are recorded by resistance strain gauges as the inside is progressively machined away. This method was applied to a section from General Atomic extruded tube No. 2380-58. The results showed that both tangential and longitudinal stresses of maximum value about 300 psi were present. The tangential stress pattern consisted of a small region of compressive stress at the inner surface, a larger

zone of tensile stress, then a compressive zone near the outside surface. This pattern is qualitatively consistent with the "cooling stresses" expected from the texture of the tube. The longitudinal stress pattern was different at two positions 90° apart, consisting of tensile stress at the inside and compressive stress at the outside in one case, and the reverse situation at the other position. This distribution may be associated with bending stresses introduced into the extruded material by uneven flow between the top and bottom of the horizontal extrusion dies. One-shot deflection tests for tangential and lontitudinal stresses gave about the right value for the maximum tangential stress, but estimates of the maximum longitudinal stresses were inconsistent with the values obtained by the boring out technique. (auth)

**27955** (HW-80567) CRACK PROPAGATION TESTS ON ZIRCALOY-2 REACTOR PRESSURE TUBING IN BOTH THE NORMAL AND HYDRIDED CONDITIONS. R. C. Aungst and L. J. Defferding (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Apr. 23, 1964. Contract AT(45-1)-1350. 27p. (CONF-512-5)

From American Society for Testing and Materials 67th Annual Meeting, Chicago, June 1964.

Whether a reactor pressure tube failure is ductile or brittle could spell the difference between an annoying incident and one producing ruinous mechanical damage to the plant. For this reason it was imperative that a test be provided to directly assess the resistance to brittle failure of Zircaloy-2 pressure tubes. Theories of brittle fracture as applied to cylindrical configurations do not appear to be well enough advanced to allow confident prediction of behavior based on indirect tests such as charpy impact, drop weight, and others. Two methods were developed for introducing a starting crack in specimens of pressure tubing under controlled conditions of temperature and stress. Using these methods data were generated defining the effects of temperature, degree of cold work, flaw size and hydrogen content on susceptibility to brittle fracture. The tests indicate that at elevated temperatures likely to be encountered in reactor operation there exists no tendency toward brittle fracture arising from defects on the order of ½ inch long. At 150°C and below susceptibility to brittle failure increases with degree of cold work. Since irradiation and cold work have similar effect on strength and ductility it seems reasonable to expect brittle fracture to occur more readily with increasing exposure to reactor environment. Hydrogen content lowers the resistance to brittle failure at room temperature of a tube containing a flaw and increases the sensitivity of the test to flaw size. Continuing tests will explore the effects of increased flaw size and hydrogen content at elevated temperatures and the effects of irradiation. (auth)

**27956** (IS-745) A STUDY OF THE STRAIN-AGING AND BRITTLE-DUCTILE TRANSITION CHARACTERISTICS OF CHROMIUM. Kenneth Edwin Solie and O. N. Carlson (Ames Lab., Ames, Iowa). Aug. 1963. Contract W-7405-eng-82. 129p.

A comprehensive study of the strain-aging and brittle-ductile transition characteristics of chromium has been carried out with the intention of determining the basic mechanisms responsible for the occurrence of these effects. In this study the strain-aging characteristics of chromium have been divided into dynamic and static phases. In studying the dynamic effects, the mechanical parameter of primary concern has been the ultimate tensile strength. This quantity was determined at various strain rates, and plots of ultimate tensile strength versus temperature were found to be characterized by the existence of double strain-aging peaks. On the basis of the activation energies associated with these peaks, it has been concluded that one peak results from the classical mechanism of a nitrogen atmosphere diffusing along with the moving dislocation. The mechanism causing the presence of the second strain-aging peak is not clear; however a possible explanation has been proposed on the basis of a pipe diffusion interaction of the interstitial atoms with the dislocation. Discontinuous yielding, a minimum in the strain-rate sensitivity, and a minimum in ductile were also observed at all strain rates tested. Chromium has been observed to exhibit the static strain-aging characteristics of a return-of-yield point and an increase in flow stress after initial straining and subsequent aging. On the basis of data obtained during this phase of the investigation, it can be concluded that nitrogen is also responsible for the return-of-yield point. The strain-age hardening phenomenon in chromium was found to be quite complex, and no firm mechanistic interpretation of this effect could be made. The brittle-ductile transition temperatures of single and polycrystalline chromium metal were studied as a function of nitrogen concentration and chromium nitride distribution. It was observed that the effect of nitrogen on the polycrystals as noted by other investigators is essentially reversed in the single crystals. Nitrogen is observed to cause an increase in the transition temperatu.. of the material in the furnace-cooled condition while little or no effect of nitrogen on the ductility transition is found in the quenched state. Further investigation of this apparent sensitivity to nitrogen distribution was done through aging of quenched polycrystal and single crystal specimens. Through comparison of these results with existing theories it has been concluded that crack propagation is the controlling factor in the brittle fracture of polycrystalline chromium while crack nucleation is the rate determining step in the single crystals. (auth)

**27957** (KAPL-2000-21(p.III.1-6)) THERMAL EXPANSION OF POLYCRYSTALLINE LANTHANUM SESQUIOXIDE AND NEODYMIUM SESQUIOXIDE. R. E. Mistler, G. L. Ploetz, and J. A. Smith (Knolls Atomic Power Lab., Schenectady, N. Y.).

In the preparation of ceramic bodies, it is important to know the thermal expansion characteristics of both the single-crystal and randomly oriented polycrystalline states of the raw material. To further define these properties, the coefficient of linear thermal expansion and thermal expansion curves from room temperature to 1050°C were determined for polycrystalline samples of lanthanum sesquioxide and neodymium sesquioxide by the dilatometer method. Previous work by Stecura and Campbell was done using a high-temperature x-ray diffractometer. Since the crystal systems of both the lanthana and neodymia used in their investigation were hexagonal, their results are presented separately for the a and c axes. The present investigation presents the data for randomly oriented polycrystalline hexagonal samples and correlates the results of both experiments by comparing the average coefficients of volume expansion. (auth)

**27958** (KAPL-2000-21(p.IV.1-10)) FATIGUE PROPERTIES OF WELD DEPOSITED Ni–Cr–Fe ALLOY 600 CLADDING. G. J. Sokol, D. F. Mowbray, and E. E. Baldwin (Knolls Atomic Power Lab., Schenectady, N. Y.).

Bending fatigue tests at room temperature and 500°F were conducted on various types of Alloy 600 cladding. The cladding material was obtained either from pressure vessel

drop-outs or weld metal deposited on flat A302-B steel plates, and in one series, porosity was introduced during welding. The results showed no significant difference between most of the test series, although the porosity of $^1/_{32}$-in. diameter in one series reduced fatigue strength by ~25%. 0.3% mean strain had no effect on the room temperature fatigue strength, and the fatigue strength at 500°F was at least equal to that at room temperature. (D.L.C.)

**27959** (ML-TDR-64-59) THERMAL CONDUCTIVITY AND TOTAL EMISSIVITY MEASUREMENTS IN THE TEMPERATURE RANGE 1000-3000°C. Michael Hoch (Cincinnati. Univ.). Feb. 1964. Contract AF33(616)-7123. 17p.

The ratio of thermal conductivities ($k_z/k_r$) and of thermal conductivities to total emissivities ($k_z/\epsilon$ and $k_r/\epsilon$) have been measured for anisotropic ZT-type graphite in the temperature range 1000 to 2000°C. The emissivity of a sample changes even if it is stored at room temperature for a long time. To obtain the total emissivity of a material, the ratio of specific heat to total emissivity is determined for tantalum, tungsten, molybdenum, and niobium in the temperature range 1000 to 2000°C. In all cases, it is found that $C_p/\epsilon$ is a constant, independent of temperature This permits an easy and accurate determination of the total emissivity of any material. (auth)

**27960** (MSAR-63-116) THERMOPHYSICAL PROPERTIES OF RUBIDIUM AND CESIUM. F. Tepper, A. Murchison, J. Zelenak, and F. Roehlich (MSA Research Corp., Callery, Penna.). [196?]. 41p. (CONF-274-2)

From 3rd Annual High Temperature Liquid Metal Heat Transfer Technology Conference, Oak Ridge, Tenn., Sept. 1963.

The following properties of liquid and gaseous Rb and Cs are to be measured to 2000°F: vapor pressure, density, specific heat, PVT of vapor, viscosity, and thermal conductivity. Techniques are being developed for the determination of trace impurities in alkali metals. The measurements that have been completed and are reported are the vapor pressure of Rb and Cs, density and electrical resistivity of liquid Rb, and specific heat of liquid Rb and Cs. The density of liquid Cs was measured to 708°F. (D.L.C.)

**27961** (NAA-SR-9374) EQUILIBRIUM DISSOCIATION PRESSURES OF THE DELTA AND EPSILON PHASES IN THE ZIRCONIUM–HYDROGEN SYSTEM. J. W. Raymond (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). May 31, 1964. 31p.

Pressure-temperature isochores were obtained for zirconium–hydrogen alloys, spanning the H/Zr atom ratio range of 1.430 to 1.910. The studies were confined to the temperature limits of 300 to 900°C, and the pressure limits of 0.01 to 10.0 atm. An expression equating equilibrium dissociation pressure to temperature and composition was determined, as was the heat of solution function over the range of composition studied. Based on the results of the study, a modification to the zirconium–hydrogen binary phase diagram was proposed, involving construction of a single line, extending upward in temperature from the $ZrH_{1.59}$ composition, denoting onset of the $\delta \rightarrow \epsilon$ transformation, in place of the two-phase ($\delta + \epsilon$) region appearing on recent diagrams. It is considered that the two-phase region exists only in ternary or higher-order alloy systems, generally resulting from contamination with oxygen, carbon, or nitrogen. (auth)

**27962** (NASA-TN-D-2287) EFFECTS OF INTERSTITIAL IMPURITIES ON THE LOW-TEMPERATURE TENSILE PROPERTIES OF TUNGSTEN. Joseph R. Stephens (National Aeronautics and Space Administration. Lewis Research Center, Cleveland). June 1964. 14p.

Results showed that both oxygen and carbon produced a marked increase in the ductile to brittle transition temperature of polycrystalline tungsten and a much smaller increase in the transition temperature of single-crystal specimens. Oxygen produced a decrease in the strength properties of polycrystalline specimens with little effect on the strength of single crystals. Carbon additions resulted in a marked increase in the yield strengths for both types of specimens. The results suggest that oxygen embrittlement in tungsten is caused by grain-boundary segregation, while carbon embrittlement results from a dislocation locking mechanism. (auth)

**27963** (ORNL-2496) METALLOGRAPHY AND AGING CHARACTERISTICS OF HASTELLOY B. J. R. Riddle and R. J. Gray (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 38p.

Investigations of the high-temperature properties of Hastelloy B have shown that age hardening strongly influences the mechanical properties of the material. The microstructures and hardness data for isothermal heat treatments at five temperatures between 700 and 1000°C for periods to 1600 hr are shown. To show the effects of aging, etching conditions are duplicated as closely as possible, and the details of the microstructures are shown at high optical magnifications and in electron micrographs. Polishing and etching techniques are also described. The largest increase in hardness occurred at the lowest temperature of the investigation, 705°C, due to precipitation in the form of Widmanstätten platelets. Evidence is presented that indicates the platelets to be $Ni_3Mo$. The spheroidal carbides in wrought Hastelloy B are shown to have an $M_6C$ structure. (auth)

**27964** (ORNL-3553) ANALYSIS OF STRESS AND STRAIN IN SPHERICAL SHELLS OF PYROLYTIC CARBON. J. W. Prados and J. L. Scott (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 52p.

A technique was developed for calculating profiles of the tangential stress and strain components that occur in spherical pyrolytic carbon shells as a result of thermal expansion or radiation-induced dimensional changes. The method is based on a mathematical analysis of stress and strain in a spherically symmetric, anisotropic medium having hexagonal symmetry in which the crystallographic axes coincide with axes of geometrical symmetry. The results should be of value in the development of pyrolytic carbon-coated reactor fuel particles, particularly for the selection of optimum design parameters and for the planning and interpretation of failure tests. A digital computer program was prepared for calculating tangential stress and strain profiles in particle coatings and plotting them as a function of position. The results of thermal stress calculations are presented for pyrolytic carbon coatings of three different thicknesses at temperatures below and above the deposition temperature. The CDC-1604-A and Calcomp plotter were used; the code is compatible with the IBM 709-7090 processors. (auth)

**27965** (ORNL-3556) THERMAL CONDUCTIVITY OF URANIUM DIOXIDE AND ARMCO IRON BY AN IMPROVED RADIAL HEAT FLOW TECHNIQUE. T. G. Godfrey, W. Fulkerson, T. G. Kollie, J. P. Moore, and D. L. McElroy (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 72p.

A description of an improved radial heat flow technique for measuring the thermal conductivity of solids in the

range −57 to 1100°C is presented. The technique yielded results with a probable accuracy of ±1.5% and a reproducibility of ±0.1% in this range. Meaningful measurements were limited to 1100°C by Pt vs Pt−10% Rh thermocouple instability, although the apparatus was structurally sound to 1400°C. The thermal conductivity of polycrystalline $UO_2$ was measured from −57 to 1100°C and reveals a maximum in k near room temperature caused by the decrease of the lattice specific heat. The thermal resistance, 1/k, shows a linear dependence with temperature from 200 to 1000°C, which is expected for an insulator well above its Debye temperature. The slope of the 1/k-temperature plot is 0.0223 cm/w, and this is independent of impurity content, although the intercept is sensitive to impurity content. The thermal conductivity of polycrystalline Armco iron was measured between 100 and 1000°C and was found to be within ±2 to 3% of the best values reported in the literature. The temperature dependence of the thermal conductivity of iron is largely controlled by the electronic contribution, which was deduced from electrical conductivity measurements. The thermal conductivity of iron can be represented by four linear equations for the temperature ranges 0 to 436, 436 to 786, 786 to 910, and 910 to 1000°C. A slope change of 30% at 436°C may be coupled to a minimum in the thermoelectric power of iron near this temperature. A minimum in the thermal conductivity occurs near 786°C and is associated with the Curie transformation. A 4% decrease in the thermal conductivity was observed at the $\alpha$-$\gamma$ transformation (910°C), and this is associated with a change in the lattice contribution to the total thermal conductivity. (auth)

**27966** (ORNL-3600) EFFECTS OF HYDROGEN ON THE HIGH-TEMPERATURE FLOW AND FRACTURE CHARACTERISTICS OF METALS. H. E. McCoy, Jr. (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 289p.

The results of a study directed toward an evaluation of the high-temperature mechanical behavior of several metals in hydrogen are reported. Comparative creep-rupture testing in argon and hydrogen environments was the primary method used to evaluate the mechanical behavior. The materials studied included two heats of Inconel, Nickel 200, Nickel 270, an electron-beam zone-refined melt of nickel, high-purity copper, Armco iron, electrolytic iron, and type 304 stainless steel. All of the nickel-base materials and the copper exhibited inferior creep resistance in hydrogen, and the iron-base materials were not influenced by environment. Hydrogen had a large effect on pure nickel and copper with the magnitude decreasing with decreasing purity. This environmental effect was characterized, in general, by the following observations: (1) At the same stress and temperature, the minimum creep rate is greater in a hydrogen environment than in argon. (2) The rupture life is less in hydrogen than in argon at an equivalent stress and temperature. (3) The rupture ductility is not influenced. Several additional experiments were run in an effort to determine the responsible mechanism. These experiments included measurement of permeation of hydrogen through Inconel, measurement of the surface energy of nickel in argon and in hydrogen, comparison of sintering rates of nickel powder in argon, hydrogen, and vacuum, comparison of void formation in diffusion couples of iron and nickel annealed in argon and hydrogen environments, comparison of diffusion of carbon in nickel in hydrogen and in argon environments, measurement of the rate of self-diffusion of cobalt-60 in nickel in argon and hydrogen, and transmission electron microscopy on thin nickel creep specimens. The mechanism thought to be most consistent with the experimental observations was based on the interaction of hydrogen with dislocations. Although several details of the mechanism are lacking, this mechanism qualitatively accounts for most of the experimental observations. (auth)

**27967** (ORNL-3617) DIFFUSION IN BODY-CENTERED CUBIC METALS ZIRCONIUM, VANADIUM, NIOBIUM, AND TANTALUM (thesis). Ted Sadler Lundy (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 162p.

Submitted to Univ. of Tennessee.

This study was initiated with the objective of defining the characteristics of diffusion in body-centered cubic metals with particular attention being given to the temperature dependence of the diffusion coefficient and the applicability of various empirical relationships. The first experiments were directed to the resolution of large differences in self-diffusion coefficients reported by several investigators for beta zirconium. These differences as reported in terms of $D_0$ and Q in the Arrhenius-type expression, $D = D_0 \exp(-Q/RT)$, have been explained in terms of the failure of this equation to describe such data over large temperature intervals. Both $D_0$ and Q were found to be temperature dependent for diffusion in this system. The empirical rules involving melting point, heat of fusion, etc., were therefore found to be inapplicable because they assume the activation energy Q to be constant with temperature. This study has shown that the preexponential factor $D_0$ varies with a power of temperature and that Q varies linearly with temperature for diffusion of both zirconium-95 and niobium-95 in beta zirconium. Since the discovery that the Arrhenius equation does not adequately describe the temperature dependence of the diffusion coefficient in beta zirconium has far-reaching implications, it was important to study other systems over wide temperature intervals to find if the equation is, in general, inapplicable. Similar results were obtained for diffusion of vanadium-48 in vanadium. This work was done to check the possibility that the phase transformation in zirconium might somehow be responsible for the unusual results. It clearly shows that such is not the explanation. Then, an experimental study of the diffusion of niobium-95 in niobium was begun. For the high-temperature diffusion anneals (T > 1500°C), it was possible to use standard sectioning techniques to obtain diffusion coefficients. For the lower temperature work, it was necessary to develop a new technique for sectioning. This method, based on anodizing and stripping of the thin anodic layers, permits measurement of diffusion coefficients as low as $10^{-20}$ square centimeters per second for diffusion in both niobium and tantalum. This resolution is at least five orders of magnitude smaller than those previously obtained by a direct method. Using this technique, measurements were made down to about 1000°C. These precision measurements permitted a detailed study of the so-called near-surface effect previously reported and showed that a penetration plot for diffusion from a thin source of isotope has three regions associated with it—a near-surface region, a normal region, and a short-circuiting region. The surface effects were shown to be much more common than had been generally realized. Upon analyzing the normal regions of each penetration plot, diffusion coefficients for niobium-95 in niobium were found to follow the Arrhenius-type expression over nearly seven orders of magnitude from 2450 to about 1200°C. Deviations occurred at lower temperatures, but these deviations may be due to interaction of the different regions of diffusion. Oxygen content varia-

tions were found to have little effect on the diffusion of niobium-95 in niobium. Cursory data were also obtained for the diffusion of tantalum-182 in niobium. A few experiments have been done on the diffusion of niobium-95 in tantalum at low temperatures. These tests, accomplished by using the anodizing and stripping technique, clearly show the near-surface region at temperatures of 1050 to 1250°C. (auth)

**27966** (PWA-2309) DETERMINATION OF THE EMISSIVITY OF MATERIALS. Annual Progress Report, January 1–December 31, 1963. (Pratt and Whitney Aircraft Div., United Aircraft Corp., Hartford, Conn.). Contract NASw-104. 172p.

A screening rig was constructed to enable evaluation of coating behavior at elevated temperatures so that coating volatilization in the emittance rigs could be avoided. Three materials have been tested to date, namely, Kennametals K-151A and K-162B, and iron titanate. The Kennametals were found to be stable up to 1600°F and the iron titanate up to 2000°F. Emittance values were obtained for several materials and were compared with previously obtained values to determine reproducibility. These materials included crystalline boron, oxidized Kennametals K-151A and K-162B, calcium and iron titanates, nickel-chrome spinel, and silicon carbide. Data from all of these specimens were in good agreement with that obtained previously except for that of the crystalline boron (which was slightly lower), one of the nickel-chrome spinel coatings (which was slightly higher), and one of the calcium titanate coatings (for which the emittance behavior was irregular). In addition, tests were run on a spinel enamel and on AISI-310 stainless steel and tantalum to evaluate the operation of the total hemispherical emittance rig. Tests of four coated radiator segments exposed to temperatures between 650 and 700°F and vacuum for periods ranging from 12,700 to 15,000 hours were completed and a post test analysis was made. Analysis included mechanical, metallographic, and x-ray-diffraction testing as well as residual gas analyses and vacuum chamber leak testing. The analyses confirmed that, in general, the segments withstood the extended exposure to high temperature and vacuum satisfactorily. Methods for applying silicon carbide coatings by aluminum phosphate bonding were investigated, but, although some improvement was realized, a satisfactory technique has not been developed. Difficulties encountered with the total hemispherical emittance rig were resolved. Emittance data are reported. Materials included are Hastelloys C and X; oxidized Kennametals K-151A and K-162B; titanates of barium, calcium, iron, iron with alumina, and strontium; and silicon carbide. (auth)

**27969** (TID-19263) DETERMINATION OF THE MIGRATION ENERGY OF INTERSTITIAL ATOMS IN GOLD. J. A. Venables and R. W. Balluffi (Illinois. Univ., Urbana). [1963]. Contract [AT(11-1)-1198]. 6p.

The migration of interstitial atoms in gold was studied from in situ low-energy argon ion bombardment in an electron microscope at various temperatures. Much of the damage was visible by electron transmission in the form of interstitial dislocation loops lying within about 100 Å of the bombarded surface at –100 to 30°C. (R.E.U.)

**27970** (TID-20637) THE BARIUM–SODIUM PHASE SYSTEM (thesis). Raymond Michael Stevens (Syracuse Univ., N. Y.). May 1964. Contract AT(30-1)-1578. 114p.

The barium–sodium phase system was thoroughly investigated from 100 at. % barium to 100 at. % sodium by means of thermal analysis, differential thermal analysis, recording high-temperature densitometer studies, and x-ray diffraction techniques. High purity sodium (m.p. 97.5°C) and barium (m.p. 729°C) were used in this investigation. The barium–sodium system has two compounds: BaNa, formed incongruently through a peritectic reaction at 197°C extending from 23 to 95 at. % barium; and $BaNa_4$, which is formed through a peritectoid reaction at 65°C and over the composition range 1.6 to 25.0 at. % barium. The compound BaNa crystallizes in the orthorhombic system with unit cell dimensions $a_0 = 4.26$, $b_0 = 5.88$, and $c_0 = 9.65$ A. The compound $BaNa_4$ crystallizes in the tetragonal system with unit cell dimensions $a_0 = b_0 = 9.19$ and $c_0 = 17.28$ A. The solid solubility of barium in sodium is of the order of 0.5 at. % barium at room temperature while the solid solubility of sodium in barium is 3 at. % sodium at room temperature. Sodium is extensively soluble in BaNa, however, barium is not. A eutectic occurs at 5.5 at. % barium. The eutectic temperature is 82°C and extends over the composition range 1.0 to 27.0 at. % barium. (auth)

**27971** (WADD-TR-61-72(Vol.XXXV)) RESEARCH AND DEVELOPMENT ON ADVANCED GRAPHITE MATERIALS. VOLUME XXXV. METHODS OF MEASURING MECHANICAL PROPERTIES OF GRAPHITE IN THE 20° TO 2700°C TEMPERATURE RANGE. M. B. Manofsky and R. B. Dull (National Carbon Co. Advanced Materials Lab., Lawrenceburg, Tenn.). June 1963. Contract AF33(616)-6915. 54p.

A description is given of methods and procedures for measuring short-time ultimate tensile, compressive, shear, and flexural (modulus of rupture) strengths of graphite, and the stress-strain relationships in tension, compression, and shear in the 20 to 2700°C range. Also, a description is given of a method being developed for determining Poisson's ratio in tension and compression at room and elevated temperatures. (auth)

**27972** (EURAEC-1043) DIFFUSION OF RARE GASES IN SOLIDS. Quarterly Report, January–March 1964. (Hahn-Meitner-Institut fur Kernforschung, Berlin). Apr. 1964. Work Performed under United States–Euratom Joint Research and Development Program. Contract 028-64-1 TEE(R+D). 31p. (A translation)

The activation energy for Xe diffusion in $UO_2$ single crystals (Hanford) in experiments under an atmosphere of He with 5% $H_2$ was found to be about 66 kcal/mole between 1000 and 1800°C, if the strong evaporation above 1700°C were taken into account. Experimental evidence for trapping of rare gas atoms in $CaF_2$ damaged by intense neutron irradiation is given. The activation energy for Ar diffusion in KCl single crystals was found to be about 62 kcal/mole below 400°C and about 10 kcal/mole above 400°C only. 'auth)

**27973** NEUTRON DIFFRACTION INVESTIGATION OF $U_3O_8$. B. O. Loopstra (Reactor Centrum Nederland, Petten (N.H.), The Netherlands). Acta Cryst., 17: 651-4 (June 10, 1964).

A polycrystalline sample of orthorhombic $U_3O_8$ was investigated by neutron diffraction in order to resolve discrepancies between previous single-crystal x-ray and powder neutron investigations. The space group is Amm2 ($C_{2v}^{14}$). The uranium atoms are surrounded by six oxygen atoms in close contact at distances between 2.07 and 2.23 Å, with a seventh oxygen atom at 2.44 Å for the U(1) atom and at 2.71 Å for the U(2) atom. (auth)

**27974** STRUCTURAL RELATIONSHIPS IN BERYLLIUM–TITANIUM ALLOYS. E. Gilliam (General Electric Co. Ltd., Wembley, Eng.), H. P. Rooksby, and L. D. Brownlee. Acta Cryst., 17: 762-3(June 10, 1964).

During investigations of alloys of Be carried out by pow-

der methods, Be-rich alloys of Be and Ti consistently showed the presence of a constituent of tetragonal structure. It was also noticed that the alloy $Be_{12}V$ gave a very similar powder pattern, indicative of an isostructural character. By analogy with the structure of $Be_{12}V$ (and also that of $Be_{12}Cr$) it is justified in assuming that tetragonal $Be_{12}Ti$ has the A6 $Mn_{12}Th$ structure, space group $I_4/mmm$. Data are tabulated. (P.C.H.)

**27975** POWDER INDEXING AND LATTICE CONSTANTS FOR $ThC_2$. P. K. Gantzel and N. L. Baldwin (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Acta Cryst., 17: 772-3(June 10, 1964).

Data on powder indexing and lattice constants for $ThC_2$ are tabulated. Two sets of indexes are given, one based on the monoclinic cell of others and the other derived from the index transformations H = h + 1 and L = h − 1. (P.C.H.)

**27976** THE ZIRCONIUM–COBALT ALLOY SYSTEM. W. H. Pechin, D. E. Williams, and W. L. Larsen (Ames Lab., Ames, Iowa). Am. Soc. Metals, Trans. Quart., 57: 464-73(June 1964). (IS-744)

The Zr–Co phase diagram was investigated by metallographic melting point, x-ray-diffraction, and thermal analysis methods. Five intermediate phases, $Zr_2Co$, ZrCo, $ZrCo_2$, $ZrCo_4$, and $Zr_2Co_{11}$ are formed. The first three melt congruently while the latter two decompose peritectically. Four eutectics are formed. The eutectics occur at 15% Co (all alloy compositions are reported on a weight percentage basis) and 980°C, 26% Co, and 1060°C, 42.5% Co and 1310°C, and 86% Co and 1230°C. The compound $Zr_2Co$ has a tetragonal structure with $a_0$ equal to 6.366 and $c_0$ equal to 5.514 Å. The ZrCo phase has a bcc structure with a lattice parameter of 3.196 Å. The phase $ZrCo_2$ is a Laves phase of the $MgCu_2$ type. This phase forms a solid solution extending from 55 to 64% Co at the solidus. The lattice parameter of $ZrCo_2$ varies from 6.960 at 55% Co to 6.878 Å at 62% Co at 1400°C. The compound $ZrCo_4$ decomposes at 1450°C and the compound $Zr_2Co_{11}$ decomposes at 1270°C. The reaction isotherms associated with the allotropic transformations of the parent metals were found to occur at 833°C for the Zr transformation and 375°C for the Co transformation. The terminal solubilities were found to be about 2.2% Co in beta Zr and 0.1 to 0.2% Co in alpha Zr. The maximum solubiltiy of Zr in Co is less than 0.5%. (auth)

**27977** TENSILE PROPERTIES OF EXTRUDED BERYLLIUM FROM −195 TO 200 C. M. I. Jacobson (Lockheed Missiles and Space Co., Palo Alto, Calif.). Am. Soc. Metals, Trans. Quart., 57: 482-93(June 1964).

The tensile strength, yield strength, and elongation of extruded Brush QMV-grade Be were measured from −195 to 200°C. Three extrusions, each of a different grain size, were obtained by using powder of three mesh sizes. Tensile specimens were cut parallel to the extrusion direction, and 45° to the extrusion direction to induce prismatic and basal slip, respectively. One group of specimens was tested as-extruded; another was tested after a solution heat treatment of 6 hr at 900°C, followed by aging for 48 hr at 700°C. The heat treatment removed some of the impurities present in solid solution in the matrix by precipitating compounds containing Fe and Al; it increased the tensile and yield strength, and introduced yield points. The tensile strength of the as-extruded material in the longitudinal direction decreased as temperature decreased below room temperature; however, the 45° samples increased in strength with decreasing temperature, and also exhibited superior tensile elongation below −100°C. This behavior was related to twinning. (auth)

**27978** EFFECT OF TITANIUM AND ZIRCONIUM ON MICROSTRUCTURE AND TENSILE PROPERTIES OF CARBIDE-STRENGTHENED MOLYBDENUM ALLOYS. W. H. Chang (General Electric Co., Evendale, Ohio). Am. Soc. Metals, Trans. Quart., 57: 527-53(June 1964).

A study was made of the intereffects of chemistry, processing, and heat treatment on the microstructure and tensile properties of five Mo-base alloys containing 1.6 to 6% Ti, 0 to 0.6% Zr, and 0.09 to 0.25% C. The nature and stability ranges of the carbides, aging kinetics, and morphology of carbide dispersion are shown to depend strongly on the concentration of Ti and/or Zr and the resulting (Ti + Zr)/C ratio, with Zr being much more influential than Ti. The effect of processing and heat treatment on the 78 to 3500°C tensile properties was determined and its interdependency with the solution and aging characteristics discussed. The strengthening effect of small Zr additions and the weakening effect of high Ti additions in carbide-strengthened alloys were established conclusively. The magnitude of these effects is shown to vary with processing and heat treatment, as dictated by the effect of Ti and/or Zr on the state of carbide dispersion. (auth)

**27979** STRAIN-INDUCED VS PRE-EXISTING PRECIPITATION IN THE Mo–TZC ALLOY. W. H. Chang (General Electric Co., Evendale, Ohio). Am. Soc. Metals, Trans. Quart., 565-7(June 1964).

Dispersion-hardening characteristics were analyzed in the precipitation-hardenable Mo–TZC alloy (analyses 1% Ti, 0.1% Zr, 0.14% C, bal Mo). At room temperature, the carbides in the recrystallized condition of Mo–TZC exerts a moderate strengthening effect; the true stress increment increases with strain, reaching a constant value at about 10% strain. Similar results were obtained at 1400°F for both the recrystallized condition and the aged condition with the latter exhibiting a more potent effect owing to its more extensive dispersion. At this temperature, however, there is a decrease in strengthening effect by the preexisting dispersions, as indicated both by the attainment of the maximum stress increment at much smaller strains and by the decrease in magnitude of this increment, as compared with room temperature. The results illustrate the relative potency of strain-induced vs preexisting precipitation. (P.C.H.)

**27980** VAPORIZATION BEHAVIOR OF HIGH-MELTING POINT CARBIDES FOR THERMIONIC POWER GENERATION. L. Eberle (Battelle Institut e.V., Frankfurt am Main). Atomwirtschaft, 5: 220-6(May 1964). (In German)

A compilation was made of values of the vapor pressures and evaporation rates of a few of the high-melting-point carbides that are usable as emitter materials. (P.C.H.)

**27981** LONGITUDINAL TENSILE PROPERTIES OF H4LM GRAPHITE IN THE TEMPERATURE RANGE −253 TO 500°C. M. C. Smith, D. T. Eash, and K. McKibbin (Los Alamos Scientific Lab., N. Mex.). Carbon, 1: 181-3 (1964). (LADC-5832)

Tensile strength data are presented for a molded H4LM graphite tested in the longitudinal orientation (across the grain) at a nominal engineering strain rate of 0.0005/min in liquid H at −253°C, in liquid Ni at −196°C, and in air at room temperature, 250, and 500°C. All ultimate strength values at all of these temperatures fall within the scattering of room-temperature strength measurements. (auth)

**27982** CONSTITUTION DIAGRAM FOR THE NIOBIUM–TIN SYSTEM. Current Eng. Practice, 6: No. 5, 22-3(Nov. 1963).

A constitution diagram for the Nb–Sn alloy system shows

four intermediate compounds: $Nb_4Sn$, $Nb_3Sn$, $Nb_2Sn$ and $Nb_2Sn_3$. The diagram indicates the metallurgical problems to be anticipated in producing $Nb_3Sn$, which has outstanding super-conducting properties for high field strength magnets. (Rev. Metal. Lit., 21: No. 5, May 1964)

**27983** PROPERTIES OF BORON-ALLOYED STAINLESS STEELS FOR NUCLEAR REACTORS. Karl Bungardt and Rudolf Oppenheim. Dew Tech. Ber., 4: 9-12 (1964). (In German)

The effects of boron additions to stainless steels on mechanical properties and corrosion resistance were investigated. Tensile characteristics were investigated at 20 to 1200°C, notch-impact strength at 20 to 300°C and corrosion resistance to boiling $HNO_3$ of 18/11 CrNi steel plates containing 0.7 to 1.3% B. (Rev. Metal. Lit., 21: No. 5, May 1964)

**27984** NIOBIUM—THE METAL OF EXTREMES. R. T. J. Hubbard (Imperial Metal Industries, Birmingham, Eng.). Discovery, 25: No. 6, 39-43(June 1964).

A review is presented on Nb, including its discovery, atomic structure, compounds and alloys, and uses in reactors, as superconductors, and in industry. Special attention is given to the strength of Nb alloys. (P.C.H.)

**27985** USE OF HEATING BY ELECTRON BOMBARDMENT TO INVESTIGATE THE COEFFICIENT OF HEAT CONDUCTIVITY IN HIGH-MELTING-POINT ALLOYS AND COMPOUNDS. D. L. Timrot and V. E. Poletskii (Scientific Research Inst. of High Temperatures, USSR). High Temp., 1: 147-51(Sept.-Oct. 1963). (Translated from Teplofiz. Vysokikh Temp., 1: 168-72(Sept.-Oct. 1963)).

A method is described for determining the coefficient of heat conductivity in high-melting-point alloys and compounds by electron bombardment, which makes it possible to make measurements at extremely high temperatures and set up experiments for study of samples with a relatively simple shape (cylinders 60 to 70 mm long and 12 to 16 mm in dia). The simple (technologically) geometry of the samples makes the method particularly suited for investigations of materials produced by the powder metallurgy method. (P.C.H.)

**27986** THERMOELECTRIC STABILITY OF THERMOCOUPLES MADE OF TUNGSTEN–RHENIUM ALLOYS AT HIGH TEMPERATURES. V. I. Lakh, B. I. Stadnyk, and Yu. B. Kuz'ma (Moscow State Univ.). High Temp., 1: 267-72 (Sept.-Oct. 1963). (Translated from Teplofiz. Vysokikh Temp., 1: 299-305(Sept.-Oct. 1963)).

Studies were made on the factors that affect the stability of the thermoelectric characteristics of W–Re alloys. It was concluded that W–Re thermocouples can be safely used in vacuum, argon, and hydrogen. (auth)

**27987** PRODUCTION OF MONOCRYSTALS OF REFRACTORY METALS BY CZOCHRALSKI'S METHOD IN CONJUNCTION WITH ELECTRON-BEAM HEATING. N. G. Sushkin (Moscow Power Inst.). High Temp., 1: 278-9 (Sept.-Oct. 1963). (Translated from Teplofiz. Vysokikh Temp., 1: 313-15(Sept.-Oct. 1963)).

Czochralski's method in conjunction with electron-beam heating is described for the production of pure monocrystals of refractory metals. The method is of interest because the crystal is pulled from a pool of the melt. Contamination by the crucible is avoided if a pool of molten metal is maintained on the surface of a piece of the solid. The seed is brought into contact with the melt, heat is removed, and the crystal starts to grow. The seed is raised as the crystal grows, and the solid is gradually melted to maintain the pool. This is when electron-beam heating is used. (P.C.H.)

**27988** HEAT CONDUCTIVITY OF ELECTRICAL CONDUCTIVITY OF TANTALUM AND NIOBIUM. N. Z. Pozdnyak and K. G. Akhmetzyanov (All-Union Polytechnical Correspondence Inst., USSR). High Temp., 1: 280-2(Sept.-Oct. 1963). (Translated from Teplofiz. Vysokikh Temp., 1: 316-18(Sept.-Oct. 1963)).

The results of measurements of heat conductivity and electric conductivity of Ta and Nb at temperatures between 273 and 1273°K are reported. The heat conductivity of Ta and Nb increases with increasing temperature. The electric conductivity of Ta and Nb decreases with increasing temperature according to a nonlinear relation. The results show that the heat conductivity in Ta and Nb is due to current carriers and to the conductivity of the lattice. The electric conductivity of both metals is very low. (P.C.H.)

**27989** PHOTOCONDUCTIVITY OF CdS AND ITS APPLICATION TO THE X-RAY PICK-UP TUBE IN A TELEVISION CIRCUIT. Shoichi Takekawa (Hirosaki Univ., Japan). Hirosaki Igaku, 15: 356-62(Oct. 25, 1963). (In Japanese)

In preliminary tests for the preparation of Vidicon type direct pick-up tubes for x rays, the photoconductivity of a CdS crystal induced by x radiation was measured, using a direct current amplifier. The sensitivity and linear response of the direct current amplifier are shown under various conditions, as are photocurrent outputs for various voltages and currents of x-ray tubes. The photocurrent in CdS increased linearly according to the x-ray intensity, and at the same time, some differences, depending on the duration and the sensitivity of the pre-irradiation with x-rays, were noted in the sensitivity level of CdS. Therefore, it is anticipated that, as a sensitive material, CdS will be applicable to the direct pick-up x-ray television camera. (BBB)

**27990** NEUTRONOGRAPHIC DETERMINATION OF ATOMIC MAGNETIC MOMENTS IN IRON–NICKEL ALLOYS CONTAINING MOLYBDENUM, SILICON AND COPPER. I. M. Puzei, V. I. Goman'kov, and A. A. Loshmanov. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 440-3(Mar. 1963). (In Russian)

Previous studies of the partial magnetic moments of Fe–Ni alloys indicated that these magnetic moments are markedly higher than those of the corresponding pure elements. The problem was further examined by determining the effect on the partial magnetic moment of the nonferromagnetic elements, such as Mo, Si, and Cu, added to the pure metals and to the alloys. In order to determine the difference of magnetic moments, the magnetic component of the diffusion scattering of the neutrons was measured, using an experimental arrangement previously developed by (V. I. Goman'kov et al. Fizika Metallov i Metallovedenie 14: 26(1962)). In order to eliminate the effect of multiple scattering, the neutron collimation angle was increased to 2°. The measurements were carried out at 77°K, thus avoiding the thermal diffusion scattering effect of the neutrons. The measurements consisted in the determination of the magnetic scattering cross section of neutrons on alloys containing 65% Ni, 30% Fe and 5% of either Mo or Si. It was found that Si exerts the strongest effect on the partial magnetic moment of Fe; Mo had only a slight effect on Fe but lowered the value of the magnetic moment of the Ni more markedly than Si. Similar tests revealed that Cu has only a slight effect on the magnetic moment of Fe. (TTT)

**27991** THE MAGNETO-ELASTIC PROPERTIES OF RARE EARTH FERROMAGNETIC COMPOUNDS (REFC). K. P. Belov, R. Z. Levitin, S. A. Nikitin, and A. V. Ped'ko (Moscow Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 519-28(Mar. 1964). (In Russian)

Helical antiferromagnetism was observed in Dy, Tb, Er, Ho, and Tm. A spiral or helical magnetic structure in these metals led to a sharp decrease in magnetization at temperatures of $\theta_1$ to $\theta_2$ ($\theta_1$ is the temperature at which helical antiferromagnetism occurs, and $\theta_2$ is the temperature, where magnetic ordering is disrupted). A threshold magnetic field $H = H_{cr}$ disrupts the helical antiferromagnetism. Studies of various magneto-elastic phenomena gave information on the nature of the spiral magnetic ordering. The longitudinal $\lambda_{||}$ and transverse $\lambda_{\perp}$ magnetostriction was given at $T < \theta_1$ and also at $T > \theta_1$ ($\theta_1 = 85°K$). The value of $\lambda_{||}$ was about $10^{-3}$ in a field of 15,000 Oe (far from saturation). The value of $\lambda_{||}$ might go to $5000 \times 10^{-6}$ near saturation. Anomalies were also observed in the elastic modulus and the shear coefficient of Dy, Ho, Er, and Gd. The application of a uniform pressure of 1800 atm in a magnetic field of 3100 Oe resulted in a decrease of 7° of the transition point $\theta_1$ compared to the value of $\theta_1$ at 1 atm. The data were taken from the literature. (21 references). (TTT)

**27992** THE EFFECT OF UNIFORM COMPRESSION ON THE MAGNETIZATION OF THE RARE EARTH METALS. L. I. Vinokurova and E. I. Kondorskii. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 537-9(Mar. 1964). (In Russian)

Samples of Gd and Dy were subjected to pressures of 1800 and 5000 atm at 78°K in a bomb. Gd was subjected to pressures of 2150 and 5000 atm at 243°K. The magnetization was measured by a photoelectric fluxmeter in magnetic fields of 2 to 16 kOe created by an electromagnet. Saturation was attained in a field of about 10,000 Oe. At a pressure of 1800 atm and 78°K near the region of saturation, the change in specific magnetization $\sigma^{-1}$ ($\Delta\phi/\Delta p$) = $+6.7 \pm 0.4 \times 10^{-7}$ for Gd; at 5000 atm $\phi^{-1}$ ($\Delta\phi/\Delta p$) = $+6.4 \pm 0.4 \times 10^{-7}$. Thus, the effect was proportional to the change in pressure. The average value of $\sigma_s^{-1}$ ($\Delta\sigma_s/\Delta p$) = $-1.9 \pm 0.4 \times 10^{-7}$ atm$^{-1}$ for Gd, which in size and magnitude agreed with the results of the measurement of the magnetostriction of Gd. The value of $\sigma^{-1}$ ($\Delta\sigma/\Delta p$) at p = 5000 atm was equal to $-2 \pm 0.1 \times 10^{-5}$ atm$^{-1}$ for Dy, and for p = 1800 atm, $\sigma^{-1}$ ($\Delta\sigma/\Delta p$) = $-2.5 \pm 10^{-5}$ atm$^{-1}$. The magnetization of Gd and Dy decreased under uniform compression. On approaching the Curie point, the value of $\sigma^{-1}$ ($\Delta\sigma/\Delta p$) for Gd increases as in the d-metals iron and nickel. (TTT)

**27993** THE EFFECT OF MAGNETIC ORDER ON THE ELECTRIC AND GALVANOMAGNETIC PROPERTIES OF THE RARE EARTH METALS. N. V. Volkenshtein, G. V. Fedorov, and V. E. Startsev (Inst. of Metal Physics, Academy of Sciences, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 540-4(Mar. 1964). (In Russian)

The electric conductivity $\rho$ and the Hall coefficient R were determined on the same pure rare earth metal samples over a wide range of temperatures down to the temperature of liquid helium. The lanthanides can be divided into three groups according to the variation of electric resistance with temperature. La, Ce, Pr, Nd, and Yb belong to the group, where the electric resistance does not vary linearly with temperature. Sm, Gd, Tm, Dy, Ho, Er, and Tb showed a characteristic break in a plot of electric resistance versus temperature on going from a paramagnetic to an antimagnetic state. The behavior of Eu was complex. The electric resistance of Eu dropped sharply below the transition from a paramagnetic to an antiferromagnetic state, and the behavior became complex near the transition into the paramagnetic region. The number of current carriers in the rare earth metals was determined from measurements of the Hall effect, and are given in parenthesis after the symbol for the element (a − sign indicates electron conduction, and a + sign indicates hold conduction): La(− 2.9), Ce(+1.6), Pr(+3), Nd(+2.1), Eu(+0.17), Gd(− 2.1), Tb(− 2.4), Dy(− 1.5), Ho(− 0.94), Er(− 2.1), Tu(− 1.1), Yb(+0.69), and Lu(− 3.5). The elements from Ce to Eu showed hole conduction, and the others showed electron conduction with the exception of Yb. The Hall effect was very sensitive to the state of magnetic order in the rare earth element. (TTT)

**27994** DETERMINATION OF SURFACE TENSION OF W, Mo, AND Re. A. I. Pekarev. Izv. Vysshikh Uchebn. Zavedenii, Tsvetn. Met., No. 6, 111-13(1963). (In Russian)

The surface tension of commercially pure W, Mo, and Re was determined by the metal drop method which consists of fusion of the rod tips by an electron beam heater and calculation of the relationship between the diameter of the rod, volume of the metal drop, and specific weight of the drop. (TCO)

**27995** HEAT CAPACITY OF PLUTONIUM MONOCARBIDE FROM 400° TO 1300°K. O. L. Kruger and H. Savage (Argonne National Lab., Ill.). J. Chem. Phys., 40: 3324-8 (June 1, 1964).

The heat content of PuC above 298°K was measured with an isothermal drop calorimeter. No discontinuities were observed in the heat-content-vs-temperature curve for which an equation was obtained. An equation for the heat capacity was derived from the calculated enthalpy equation. Values of the change in enthalpy, heat capacity, and entropy increments are given up to the melting point of PuC. Corrections of the enthalpy data for the self-heating of plutonium and the defect structure of PuC are described. (auth)

**27996** SPACE CHARGE IN GROWING OXIDE FILMS. IV. RATE EFFECTS DEDUCED BY AN AVERAGING TECHNIQUE. A. T. Fromhold, Jr. (Sandia Lab., Albuquerque, N. Mex.). J. Chem. Phys., 40: 3335-43(June 1, 1964).

An analysis of nondiffusing and diffusing space-charge effects in growing oxide films using simple models provides justification for the equation $L(t)^2_{\infty} = L^2_{\infty}[1 - \exp(-t/\tau)]$ as a first approximation for describing film growth, where L(t) is the film thickness and t is the time of oxidation. The limiting film thickness squared $L^2_{\infty}$ and the pseudo rise-time $\tau$ are functions of the space-charge concentration and are temperature-dependent, increasing linearly with temperature for most cases. Space-charge effects for a given defect concentration are predicted to be more important at low temperatures; growth tends to become parabolic at higher temperatures. (auth)

**27997** VAPOR PRESSURE OF MOLYBDENUM. P. A. Vozzella, A. D. Miller, and M. A. DeCrescente (Pratt and Whitney Aircraft, Middletown, Conn.). J. Chem. Phys., 41: 589-90(July 15, 1964).

The vapor pressure of molybdenum was determined over the temperature interval 2140 to 2535°K. (C.E.S.)

**27998** THE LATTICE PARAMETERS OF SOME δ- AND ϵ-PLUTONIUM ALLOYS. J. A. C. Marples (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Phys. Chem. Solids, 25: 521-34(June 1964).

A high temperature x-ray diffractometer was used to measure the lattice parameters of δ- and ϵ-plutonium alloys with zirconium, hafnium, scandium, and uranium. These results, and others reported in the literature, are presented as isothermal lattice parameter versus composition curves and show marked deviations from Vegard's law, zirconium even causing maxima in the curves for both δ- and ϵ-alloys. It is shown that solutes with valencies less than that of plutonium give positive deviations from Vegard's law while those with greater valencies give nega-

tive deviations. The effects of electronegativity and compressibility are considered and it is shown that these cannot explain the results. The lattice parameter versus temperature curves for some δ-phase plutonium–zirconium alloys were fitted to an equation proposed by Rocher and Friedel, which explains the form of the curves, suggesting that the negative expansion coefficient is caused by a thermally activated transition from one level to another. The activation energy is shown to increase more slowly with zirconium than with aluminum content as would be expected from their different valencies. (auth)

**27999** SOME EXPERIMENTS ON THE IMPROVEMENT OF MAGNOX ALLOYS USED FOR CANNING MATERIAL IN $CO_2$ GAS-COOLED REACTOR. Yoshitsugu Mishima and Naoaki Takahashi (Tokyo Univ.). Light Metals, No. 27, 68-72(Nov. 1957). (In Japanese)

As the first step to improve Magnox series alloys currently used in the Calder Hall power reactor in England as well as to develop better Mg alloys to be used for canning materials in a $CO_2$ gas-cooled reactor, several experiments were carried out. By preparing Magnox E alloy, as well as several Mg–Al–Ca–Be alloys with different amounts of Ca and Be, but less than those in Magnox E, the effect of the two elements on the properties of the alloys were confirmed. The two elements improved strength and oxidation resistance; Ca being more effective in strengthening. Substitution of Ca with other elements of lower thermal neutron absorption cross section (less than 1 barn) was studied since Ca is not recommended because of welding crack problems. Work-hardening characteristics and annealing curves were compared and little difference was found in the former among the candidate alloys without Ca. The high-temperature strength at the working temperature of the reactor, 752°F (400°C), may be improved by the addition of Zr, Zn, or Bi. (P.C.H.)

**28000** INFLUENCE OF ADDITIONAL ALLOYING ON THE PROPERTIES OF ALLOYS OF THE Mg–Nd SYSTEM. M. E. Drits, Z. A. Sviderskaya, and L. L. Rokhlin. Met. Metalloved., Fiz. Khim. Metody Issled., 14: 120-9(1963). (In Russian)

The chemical composition and mechanical properties of Mg–Nd alloys alloyed with Ag, Al, Ba, Bi, Co, Cd, Li, Mn, Ni, Sn, Si, and Zn were determined. Hardening temperatures were 480 to 535°C. (Rev. Metal Lit., 21: No. 5, May 1964)

**28001** INVESTIGATION OF THE RECRYSTALLIZATION OF Mg–Ce ALLOYS. E. S. Kadaner and A. A. Oreshkina. Met., Metalloved., Fiz. Khim. Metody Issled., 14: 130-8(1963). (In Russian)

The recrystallization of specimens cast from Mg–Ce alloys was studied by microscope, x-ray, and Vickers hardness test. The relation of hardness and grain size to annealing temperature and recrystallization temperature, activation energy, and stress-rupture resistance of Mg–Ce alloys in relation to Ce content were investigated. Effects of annealing on softening at elevated temperatures was also studied. (Rev. Metal Lit., 21: No. 5, May 1964)

**28002** INTERACTION OF NIOBIUM AND VANADIUM WITH MAGNESIUM. E. M. Savitskii, V. V. Baron, Yu. V. Efimov, and M. I. Bychkova. Met., Metalloved., Fiz. Khim. Metody Issled., 14: 139-46(1963). (In Russian)

Phase diagrams of V–Mg and Nb–Mg systems were constructed as a result of macro- and microstructural, x-ray, and thermal analysis, as well as hardness and microhardness measurements of the alloys. Mg-base alloys were prepared by various methods. Solubility of V and Nb in liquid and solid Mg was investigated. (Rev. Metal Lit., 21: No. 5, May 1964)

**28003** CONSTITUTION DIAGRAM FOR THE NIOBIUM–TIN SYSTEM. Metal Treat. Drop Forging, 31: 67-? (Feb. 1964).

The phase diagram for the Nb–Sn binary system was determined by stoichiometrically combining Nb and tin. It was found that intermetallic compounds of this system have good superconducting properties for high field strength magnets. (Rev. Metal Lit., 21: No. 5, May 1964)

**28004** LARGE PARTS OF ZIRCONIUM DIOXIDE WITH INCREASED THERMAL STABILITY. O. M. Margulis, I. F. Usatikov, and A. B. Kamenetskii. Ongeupory, No. 2, 63-7 (Feb. 1964).

Experiments on the production of large size parts from $ZrO_2$ from powders that can withstand large temperature changes are reported. Cubic $ZrO_2$ was stabilized and then 5% CaO added and the briquettes annealed at 1750°C. Porosity of the annealed material was 0.2–6%. The briquette was ground into particles measuring 0.088 mm and were then mixed with coarse particles in the ratio of 1 : 1 and humidified. Final moisture content of the mass was 5%. It was found that, using the 1 : 1 ratio of fine and coarse particles of cubic $ZrO_2$ to produce parts, these parts could not withstand one thermal cycle (1300–20°C). Addition of finely granulated monoclinic $ZrO_2$ to the mixture and the use of briquetted rather than fused oxides increased stability to thermal cycling. Tabulated data show results of experiments using mixtures of various particle sizes (2–200 microns) of cubic $ZrO_2$ with varying amounts of coarse (60 microns) and fine (2 microns) monoclinic $ZrO_2$. Mechanical and physical properties of $ZrO_2$ samples are given. It was determined that an increase of the amount of monoclinic $ZrO_2$ from 15 to 25% decreased the strength of parts at room temperature; it was decided that no more than 15% of the coarse-grain oxide should be used. The process can be recommended for industrial use. (TCO)

**28005** DYNAMICAL MODEL FOR LATTICE VIBRATIONS IN METALS. K. Krebs (EURATOM CCR, Ispra, Italy). Phys. Letters, 10: 12-13(May 15, 1964).

Calculations for a simple dynamical model for lattice vibrations in metals are presented. The model is based on a screened Coulomb interaction between ions, and the symmetry requirements are taken into account. The electrons influence the ion motion via the screening parameter of the Coulomb potential. The interaction between closed ion shells is described by a central interaction between first and second neighbors. (C.E.S.)

**28006** HYPERFINE AND ELECTRONIC HEAT CAPACITIES OF γ-MANGANESE. J. C. Ho and N. E. Phillips (Univ. of California, Berkeley). Phys. Letters, 10: 34-5 (May 15, 1964).

The hyperfine and electronic heat capacities of γ-manganese were measured over the temperature range 0.066 to 4.2°K. (C.E.S.)

**28007** AN X-RAY SEARCH FOR SPIN DENSITY WAVES IN CHROMIUM. R. J. Weiss (Army Materials Research Agency, Watertown, Mass.). Phys. Letters, 10: 45-7(May 15, 1964).

High resolution peak profile measurements were made employing Cr $K\alpha$ radiation on a single crystal of chromium to investigate the validity of two spin density wave models for the magnetic structure of chromium. (C.E.S.)

**28008** VOLUME MAGNETOSTRICTION IN GADOLINIUM SINGLE CRYSTALS. W. E. Coleman and A. S.

Pavlovic (West Virginia Univ., Morgantown). Phys. Rev., 135: A426-7(July 20, 1964). (TID-20266)

The magnetostriction of single-crystal gadolinium was measured from 77 to 325°K in magnetic fields up to 20 kOe. A preliminary result of this work is the behavior of the forced volume magnetostriction. These results were employed to obtain the partial differential coefficient of Curie temperature as a function of pressure over the above temperature range by means of the well-known thermodynamic expression due to Kornetzki. It is found that $\partial\theta/\partial P = -1.26 \pm 0.10$°K/1600 atm at 290°K. These results are compared with the results obtained by direct measurement and discussed further. (auth)

**28009** SINGLE-CRYSTAL ELASTIC MODULI AND THE hcp → bcc TRANSFORMATION IN Ti, Zr, AND Hf. E. S. Fisher and C. J. Renken (Argonne National Lab., Ill.). Phys. Rev., 135: A482-94(July 20, 1964).

The variations with temperature of the elastic moduli in single crystals of hcp Ti, Zr, and Hf were experimentally determined from 4 up to 1155°K, using an ultrasonic wave interference technique. The $c_{11}$, $c_{33}$, and $c_{44}$ differ considerably among the three metals, whereas the $c_{66}$ shear moduli for Ti and Zr are similar to within 1% between 4 and 300°K and less than 10% at 1100°K. There is very marked anisotropy in the temperature dependence of the shear moduli in Ti and Zr, $c_{66}$ decreasing by 75% between 4 and 1100°K whereas $c_{44}$ decreases by 40%. A very pronounced deviation from a linear temperature dependence of $c_{66}$ occurs at a temperature which coincides with the anomalous curvatures in the published electric resistivity data. The relatively small $c_{66}$ shear moduli at the h-c-p → b-c-c phase transformation temperatures are as expected from the transformation shear mechanisms suggested by Burger. A survey of existing elastic modulus and thermal expansion data in h-c-p metals leads to the conclusion that a relatively high temperature dependence in $c_{66}$ and the occurrence of h-c-p → b-c-c transformations are characteristic of metals with $c/a < 1.60$. It is suggested that these characteristics are due to the transverse thermal vibrations in the basal planes, and that the transformation results from anharmonic contributions to the free energy which are indicated by specific heat data. Contrary to comparison in other h-c-p metals, the Dybe $\theta$ from 4°K elastic moduli in Ti, Zr, and Hf are in excellent agreement with published specific heat data. A slight anomaly at 18°K in Ti is indicated which may be associated with published resistivity minima in Ti alloys. (auth)

**28010** MONTE CARLO CALCULATIONS PERTAINING TO THE TRANSPORT OF HOT ELECTRONS IN METALS. R. Stuart (Univ. of California, Livermore), F. Wooten, and W. E. Spicer. Phys. Rev., 135: A495-505(July 20, 1964). (UCRL-7626)

Monte Carlo calculations are applied to the problem of hot electron motion in metals, and measured values of attenuation length, L, are related to values of the mean free paths for electron-electron scattering $l_e$, and electron-phonon scattering $l_p$. Calculations are done for both specular and diffuse reflectance of electrons at the boundaries of the metal films and for values of the average loss per electron-phonon collision, $\Delta E_p$, of 0.001, 0.01, 0.02, and 0.03 ev. If the values of $l_p$ obtained from conductivity measurements are used, the following values or limits are found for $l_e$ using experimentally determined values of L for electrons with excess energies about 0.9 ev: Au, $l_e > 4000$ Å, Ag, $l_e = 900$ Å, and Pd, $l_e = 900$ Å. These results are compared with theory. (auth)

**28011** NUCLEAR METALS, PRESENT AND FUTURE. M. Salesse (Centre d'Etudes Nucléaires, Saclay, France). Rev. Met. (Paris), 61: 225-31(Mar. 1964). (In French)

A review is presented on developments in the metallurgy of the nuclear metals: Zr, Be, and U. Prospective uses of U and competitiveness of prices for electric power production are discussed. (P.C.H.)

**28012** THE RESISTIVITY OF REFRACTORY COMPOUNDS AT HIGH TEMPERATURES. G. V. Samsonov and V. S. Sinel'nikova. Soviet Powder Met. Metal Ceram., (English Transl.). No. 4, 272-4(July-Aug. 1962).

The temperature dependence of the electrical resistance of carbides of Ti, Zr, Hf, Nb, Mo, and W and borides of Ti and Zr were measured. The thermal coefficients of the electrical resistance were calculated for the measured carbides and borides. Electrical resistances were correlated with the electron structure. Tempearture measurements were made with chromel-alumel thermocouples and optical pyrometers. (Rev. Metal Lit., 21: No. 5, May 1964)

**28013** EFFECT OF URANIUM ON THE PROPERTIES OF STEEL. STUDIES ON SPECIAL ELEMENTS IN STEEL. Kiichi Narita, Atsusi Miyamoto, and Eiji Takahashi. Tetsu To Hagane, 49: 1686-94(Oct. 1963). (In Japanese)

The use of uranium as a deoxidizer and refiner of molten steel was investigated. The distribution of inclusions, austenitic grain size, forgeability, and cleanliness as affected by uranium additions was determined. Practical considerations in use of uranium such as methods of handling radioactive substances and control of chemical reactions between uranium and refractories are discussed. (Rev. Metal Lit., 21: No. 5, May 1964)

**28014** THE BEHAVIOR OF FISSION-PRODUCT GASES IN URANIUM AND URANIUM DIOXIDE. R. S. Barnes, R. G. Bellamy, B. T. Bradbury, J. B. Sayers, and A. D. Whapham (United Kingdom Atomic Energy Authority, Harwell, Berks, Eng.). Trans. Am. Nucl. Soc., 7: 89(June 1964).

**28015** THE SOLUBILITY OF HELIUM IN $UO_2$. Firooz Rufeh (Thermo Electron Engineering Corp., Waltham, Mass.), Donald R. Olander, and Thomas H. Pigford. Trans. Am. Nucl. Soc., 7: 90-1(June 1964).

**28016** RELEASE OF FISSION GAS BY SIMULTANEOUS DIFFUSION AND EVAPORATION. Stephen D. Lowe, Paul L. Chambre, and Thomas H. Pigford (Univ. of California, Berkeley). Trans. Am. Nucl. Soc., 7: 95-6(June 1964).

**28017** ELEVATED-TEMPERATURE PROPERTIES OF URANIUM CARBIDE. J. Crane and E. Gordon (United Nuclear Corp., White Plains, N. Y.). Trans. Am. Nucl. Soc., 7: 100(June 1964).

**28018** INTERACTION AND DIFFUSION IN THE $UO_2$/W SYSTEM. A. I. Kaznoff, M. J. Sanderson, and J. E. Van Hoomissen (General Electric Co., Pleasanton, Calif.). Trans. Am. Nucl. Soc., 7: 100-1(June 1964).

**28019** BEHAVIOR OF URANIUM SULFIDE FAST-REACTOR-TYPE FUEL SPECIMENS UNDER TRANSIENT HEATING IN TREAT. L. E. Robinson, C. E. Dickerman, and C. August (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 105-6(June 1964).

**28020** HIGH-TEMPERATURE EQUATION OF STATE OF URANIUM DIOXIDE. R. A. Meyer and E. B. Wolfe (General Electric Co., San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 111-12(June 1964).

**28021** CYCLIC STRAIN AND FATIGUE BEHAVIOR OF METALS IN THE CREEP RANGE. L. F. Coffin, Jr.

(General Electric Co., Schenectady, N. Y.). Trans. Am. Nucl. Soc., 7: 113(June 1964).

**28022** EFFECTS OF 1.0% SUPERIMPOSED MEAN STRAIN ON THE BENDING FATIGUE STRENGTH OF ZIRCALOY-4. D. F. Mowbray (Knolls Atomic Power Lab., Schenectady, N. Y.). Trans. Am. Nucl. Soc., 7: 113-14(June 1964).

**28023** FATIGUE-DESIGN BASIS FOR ZIRCALOY COMPONENTS. W. J. O'Donnell and B. F. Langer (Westinghouse Electric Co., Pittsburgh). Trans. Am. Nucl. Soc., 7: 114-15(June 1964).

**28024** PLASTIC DEFORMATIONS IN ATTACHED ELEMENTS SUBJECTED TO CYCLIC HEATING. David Burgreen (United Nuclear Corp., White Plains, N. Y.). Trans. Am. Nucl. Soc., 7: 115-16(June 1964).

**28025** MATERIALS FOR SUPERHEAT FUEL CLADDING—TENSILE AND METALLURGICAL INVESTIGATIONS. F. A. Comprelli (General Electric Co., San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 119-20 (June 1964).

**28026** HEAT TRANSFER IN NEARLY STOICHIOMETRIC URANIUM DIOXIDE. J. A. Christensen (Westinghouse Electric Co., Pittsburgh). Trans. Am. Nucl. Soc., 7: 128(June 1964).

**28027** PLUTONIUM AS REACTOR FUEL. U. Benedict. Umschau Wiss. Tech., 64: 304-6(May 15, 1964). (In German)

Uses of plutonium as a fuel element are discussed and reactor types for its use are described. Production of plutonium in breeder reactors and its processing are discussed. Preparation and uses of plutonium alloys and compounds are also considered. (M.C.G.)

**28028** TUNGSTEN SHEET ALLOYS WITH IMPROVED LOW-TEMPERATURE DUCTILITY. J. L. Ratliff, D. J. Maykuth, H. R. Ogden, and R. I. Jaffee (Battelle Memorial Inst., Columbus, Ohio). Trans. Met. Soc. AIME, 230: 490-500(Apr. 1964).

An experimental program was carried out to improve the low-temperature ductility of W through the combined use of dispersed oxides for grain-size control and Groups VII and VIII metal additions for matrix softening. Separate binary-alloy studies showed that increasing amounts of finely dispersed thoria or zirconia and critical amounts of Re, Os, and Ir were effective in significantly reducing the ductile-to-brittle bend transition temperature of W as well as in increasing its recrystallization temperature and decreasing its recrystallized grain size. The beneficial effects shown by each of these additions on transition temperature and grain size in binary combinations appeared to be additive in ternary combinations. Thus, combined additions of 2 to 8 vol % thoria with 5% Re, 0.87% Os, or 0.30% Ir were effective in lowering the transition temperature of W from 200 to 75°C, increasing its recrystallization temperature from 1600 to 1800°C, and decreasing its recrystallized grain size from 1175 to 6800 grains/mm$^2$. (auth)

**28029** INTERATOMIC DISTANCES AND ATOMIC RADII IN INTERMETALLIC COMPOUNDS OF TRANSITION ELEMENTS. Clara B. Shoemaker and David P. Shoemaker (Massachusetts Inst. of Tech., Cambridge). Trans. Met. Soc. AIME, 230: 486-90(Apr. 1964).

It is shown for an important class of complex transition intermetallic compounds ($\sigma$, P, R, $\delta$, and $\mu$ phases) characterized by normal coordination [CN12 (icosahedral), CN14, CN15, and CN16] that interatomic distances may be calculated to a good approximation as the sum of characteristic atomic radii. Two radii, one for major ligands and one for minor ligands, are specified for each atom, except in the case of CN12 where only a minor-ligand radius is specified. The same appears to be true of transition-metal phases of simpler structure: Laves phases (CN12, CN16), and $\beta$-tungsten phases (CN12, CN14). In the case of known examples of the more complex phases, a simple rule is given that specifies these radii. However, only a fraction of the known examples of the simpler phases obey this rule closely. To include the latter phases the rule may be modified by considering the radii as linear functions of the weighted average of the Pauling CN12 radii of the two kinds of atoms, with the radii weighted according to the overall chemical composition of the alloy. With very few exceptions interatomic distances for both the complex and the simpler transition phases can be predicted with this modified rule to within 0.06Å. (auth)

**28030** AGE HARDENING OF HAYNES ALLOY NO. 25 DETERMINED BY ELEVATED-TEMPERATURE HARDNESS TESTING. George Hallerman and R. J. Gray (Oak Ridge National Lab., Tenn.). Trans. Met Soc. AIME, 230: 593-4(Apr. 1964).

Two methods of obtaining age-hardening data were compared using 18 samples of Haynes alloy No. 25, that had been annealed for 2 hr at 2250°F (1232°C). Three groups of five samples were aged at 1400, 1650, and 1800°F (760, 899, and 982°C) for 14, 16, 32, 64, and 100 hr and then water-quenched. Comparison of the two sets of results showed that the hardness values determined at the aging temperatures were lower than the room-temperature hardness of the quenched specimens and the hot-hardness values reflected a strong temperature dependence above 1400°F. Conventional room-temperature hardness curves showed that up to 75 hr aging the 1800°F sample was the hardest, followed by the 1650 and 1400°F samples; however, hardness measurements made at the elevated temperatures showed the reverse order. (P.C.H.)

**28031** METALLOGRAPHIC AND DIFFERENTIAL THERMAL ANALYSES OF THE PURITY OF CERIUM. D. E. Etter and J. E. Selle (Monsanto Research Corp., Miamisburg, Ohio). Trans. Met. Soc. AIME, 230: 591-3(Apr. 1964).

Metallographic and differential thermal analyses were used to determine the purity of Ce. A definite correlation was noted between the melting point, amount of premelting, and the number of inclusions present in the material. It was concluded that differential thermal analysis and metallographic analysis can be sensitive tools for the qualitative determination of the purity of Ce. (P.C.H.)

**28032** PHASE TRANSITIONS IN THE SYSTEM TUNGSTEN–CARBON. George W. Orton. Trans. Met. Soc. AIME, 230: 600-2(Apr. 1964).

Phase transitions and reactions in the C–W system are discussed. Free energies of formation for three reactions in the system were calculated. A W–C phase diagram showing the eutectoid and peritectoid is presented. (P.C.H.)

**28033** DAMPING MEASUREMENTS ON SINGLE-CRYSTAL MOLYBDENUM. Randolph H. Schnitzel (Westinghouse Electric Corp., Bloomfield, N. J.). Trans. Met. Soc. AIME, 230: 609-11(Apr. 1964).

Damping measurements were made to determine whether internal-friction peaks exist in single-crystal Mo, and if so, whether the peaks can possibly be attributed to the motion of specific interstitials. A large peak was observed in a carburized crystal at 200 to 225°C. In addition to the large peak, a small subsidiary peak was observed at 275 to 325°C. The large peak was again observed at 225°C after the car-

burized specimen was heated to temperatures greater than 2000°C. Although the data suggest that the subsidiary peak could be due to the presence of C, an unequivocal assignment was not possible on the basis of existing data. (P.C.H.)

**28034** DIFFUSION AND PENETRATION OF HYDROGEN IN IRON AND STEEL. H. L. Eschbach, F. Gross, K. Mauersberger, and S. Schulien (Universität, Bonn.). Vakuum Tech., 12: 244-8(Dec. 1963). (In German)

Diffusion coefficients and permeabilities of hydrogen in low-carbon steel and different chromium–nickel steels were measured. In one series of measurements gaseous "dry" hydrogen was used, whereas in other experiments hydrogen was deposited electrolytically on the ingoing surface with the diffusion membrane acting as cathode of an electrolytical cell. From the temperature dependence of diffusion and permeation the activation energies were derived. The relation between current density and permeation in the electrolytical process was also investigated. (auth)

**28035** WETTING OF BERYLLIUM BY VARIOUS PURE METALS AND ALLOYS. R. G. Gilliland (Oak Ridge National Lab., Tenn.). Welding J. (N.Y.), 43: 248s-57s(June 1964).

The wetting behavior of liquid silver, gold, germanium, aluminum, copper, Pd–2.1 wt % Be, Zr–5 wt % Be, and Ti–6 wt % Be on the surface of solid beryllium is discussed. The experimental testing program employed the use of sessile-drop techniques for the determination of the degree of wetting and the preparation of the associated calculations. Interfacial contact angle measurements between drop and solid as a function of time, temperature, and atmosphere are presented. The results of extensive metallographic examinations determining the extent of alloying between beryllium and the liquid metals are also discussed. Surface tension calculations are presented and include values for the liquid-vapor and liquid-solid surface tensions, the work of adhesion, and the coefficient of spreading. These parameters are presented as a qualitative means of measuring the wettability of beryllium by these liquid metals. The results of the wettability study indicated that the Ti–6 wt % Be alloy had the best overall wetting characteristics. It produced the lowest contact angle, the lowest liquid-vapor and liquid-solid surface tensions, and the highest work of adhesion and spreading coefficient. (P.C.H.)

**28036** STUDY OF ZIRCONIUM EDGE OF THE ZIRCONIUM–NIOBIUM–CHROMIUM AND ZIRCONIUM–NIOBIUM–VANADIUM SYSTEMS. Ulrich Benedict (Euratom, [Mol, Belg.]) and Jean-Jacques Huet. Z. Metallk., 55: 261-5(May 1964). (In German)

Ternary alloys with a higher transformation temperature than binary zirconium–niobium alloys exist only in the immediate vicinity of the binary zirconium–chromium and zirconium–vanadium systems. The dimensional change at 600°C in a considerable range of zirconium-rich alloys is small and, consequently, it may be questioned whether such a dimensional change impairs the mechanical strength of a full element. A considerable dimensional change results in alloys of this range only at 660 to 720°C, depending on the composition. From investigation the partial diagrams, zirconium–niobium–$ZrV_2$ and zirconium–niobium–$ZrCr_2$ may be interpreted as ternary eutectoids. The $\beta$-phase may be retained metastable in ternary alloys and in binary zirconium–vanadium alloys, but not in zirconium–chromium alloys of the investigated range of compositions. (auth)

**28037** PREPARATION AND PHASE COMPOSITION OF MOLYBDENUM BORIDE. V. F. Funke and S. I. Yudkovskii. Zh. Prikl. Khim., 36: 2379-85(1963).

The effect of temperature, pressure, and reaction time on the chemical and phase composition of molybdenum boride, $Mo_2B_5$, was studied for the reactions:

$$8MoO_3 + 5B_4C + 19C = 4Mo_2B_5 + 24CO; \quad (1)$$

$$8MoO_2 + 5B_4C + 11C = 4Mo_2B_5 + 16CO; \quad (2)$$

$$2Mo + 5B = Mo_2B_5. \quad (3)$$

The mixtures were ball milled, compacted, and heated in vacuo. The optimum conditions for producing the composition closest to $Mo_2B_5$ were established for each reaction. Chemical and x-ray analysis of the reaction products indicated that: the optimum temperature and reaction time decreased from 1500°C and 2 hr in reaction (1) to 1200°C and 30 min in reaction (3); the content of the principal impurity (C) in the boride synthesized in reaction (3) was lower than that in reaction products of (1) or (2) obtained under optimum conditions; and refining of $Mo_2B_5$ by oxidation of the C impurity with $B_2O_3$ failed to produce purer $Mo_2B_5$ than reaction (1) under optimum conditions. Only one rhombohedral phase, $Mo_2B_5$, was detected in all products of the three reactions within the 1300 to 1500°C range. It is assumed that homogeneous $Mo_2B_5$ exists within the 18 to 24% B range. (OTS)

**28038** VAPORIZATION OF IRON-, NICKEL-, AND COBALT-BASE ALLOYS BETWEEN 760-980°C AND $5 \times 10^{-7}$ TO $1 \times 10^{-5}$ TORR. D. T. Bourgette (Oak Ridge National Lab., Tenn.). p.497-502 of "1963 Transactions. The Tenth National Vacuum Symposium, American Vacuum Society."

Evaporation rates of types 316, 304, and 446 stainless steel, Inconel, INOR-8, and Haynes alloy No. 25 were measured to determine their suitability for use in high vacuum. Evaporation losses increased with temperature and with the Cr and Mn concentrations in the alloy but were independent of pressure in the range investigated. For type 316 stainless steel, the alloy most thoroughly studied, the evaporation rate increased from $5.23 \times 10^{-5}$ mg/cm²/hr at 760°C to $6.60 \times 10^{-3}$ mg/cm²/hr at 980°C after several hundred hours at each temperature. The data also show that, at constant temperature, the evaporation rates decreased with time and that, the lower the test temperature, the greater was the decrease in the rate. Changes in microstructure and composition are also described. (auth)

## Radiation Effects

*Refer also to abstract 27600.*

**28039** (EURAEC-1020) RESEARCH TO DETERMINE THE LONG-TERM MECHANICAL PROPERTIES OF METALS SUBJECTED TO MECHANICAL STRESS AT ELEVATED TEMPERATURES AND NEUTRON IRRADIATION. Fifth Quarterly Report. W. Siegfried and S. Zimering (Battelle Memorial Inst. International Div., Geneva). Apr. 1964. Work Performed under United States–Euratom Joint Research and Development Program. Contract 100-62-12 RDS. 16p.

An outline is presented of studies on creep and rupture mechanisms in metals at high temperatures; analysis of creep in Cr–Mo–V steel and other metals by hot-hardness and time-to-rupture tests; and the effects of neutron irradiation on creep in Cr–Mo–V steel and other metals. (T.F.H.)

**28040** (EURAEC-1022) THE EFFECT OF RADIATION ON THE DUCTILE-BRITTLE TRANSITION IN PRESSURE VESSEL STEELS. Quarterly Report No. 13, January 1–March 31, 1964. E. Anderson, D. Brandon, D. King,

M. Malone, and J. Spreadborough (Battelle Memorial Inst. International Div., Geneva). Apr. 1964. Work Performed under United States–Euratom Joint Research and Development Program. Contract 095-62-12-RDS. 49p.

The results of a microprobe analysis of the nature of the inclusions in the materials used in the study are briefly reported. The flow stress and work-hardening behavior of dilute alloys of iron are treated in some detail: after a discussion of the various hardening mechanisms in iron, both theoretical and experimental analyses of the flow stress are given; work-hardening processes in iron are discussed theoretically and in the light of experimental data on dislocation densities obtained from transmission electron microscopy. For convenience, a distinction is drawn in the analyses between two separate hardening mechanisms: one opposing dislocation movement in the dislocation-free matrix, and the other resulting from dislocation interaction in the work-hardened material. The results show that the approximation made by ignoring the effect of one mechanism on the other cannot be justified; nevertheless, the basic mechanism controlling the flow stress is established as the elastic interaction of small clusters of interstitial atoms of carbon and nitrogen with the dislocations moving through the lattice. (auth)

**28041** (EURAEC-1046) INFLUENCE OF NITROGEN IN IRON AND STEEL UNDER FAST NEUTRON IRRADIATION. Quarterly Report No. 2, January 1–March 31, 1964. F. Rossi (Societa Ricerche Impianti Nucleari. Centro Ricerche Nucleari, Saluggia, Italy). Apr. 1964. Work Performed under United States–Euratom Joint Research and Development Program. Contract 004-63-10-TEET(RD). 17p.

Additive effects of nitrogen in Fe and steel under fast neutron irradiation are studied, with attention to sample preparation, chemical analysis, internal friction measurements, activation analysis, and magnetic measurements. (T.F.H.)

**28042** (EURAEC-1048) FISSION GAS RELEASE FROM URANIUM DIOXIDE. Quarterly Progress Report No. 13, January–March 1964. (FIAT. Sezione Energia Nucleare, Turin). Work Performed under United States–Euratom Joint Research and Development Program. Contract 021-60-9 RDI. 14p. (FN-E-43)

Experiments have been performed at high temperatures. Experimental fission-gas release data are obtained for $UO_2$ pellets. (T.F.H.)

**28043** (HW-79280(p.8.1-6)) IRRADIATION EFFECTS ON MATERIALS. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Mechanical and Physical Properties of Irradiated Materials: Flux Dosimetry. Modified cross section values have brought results between calculation and experiment into closer agreement for iron, titanium, and nickel monitors. Irradiation Damage to Zircaloy-2. Notch Tensile Properties of Zircaloy-2. Irradiation Damage to Stainless Steels. Notch Tensile Properties of AISI SS. Gas Loop Heat Exchanger Tubing. Grain Growth in Superalloys. Test Section-Mark I. Insulation Studies. Heat Transfer Studies. Tensile Specimen Holder. In-Reactor Measurements. Irradiation Effects on Fissionable Materials: Swelling of Irradiated Fissionable Materials. Controlled temperature irradiations of uranium specimens has proceeded on schedule. (auth)

**28044** (HW-80284(p.8.1-4)) IRRADIATION EFFECTS ON MATERIALS. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Mechanical and physical properties of irradiated materials, and irradiation effects on fissionable materials were studied. (R.E.U.)

**28045** (IAN-I-1) EFECTOS DE LAS RADIACIONES GAMMA SOBRE LA RESINA PERMUTIT-SK. (Effects of Gamma Radiation on the Permutit-SK Resin). Jorge Sanin Sader (Colombia. Instituto de Asuntos Nucleares, Bogota). Dec. 1961. 30p.

Permutit-SK, a polypyridinium anion exchange resin containing strong and weak base groups was irradiated in the hydroxide form with cobalt-60 gamma rays at doses up to 1,000 Megarads. Measurements were made of the loss in strong base capacity, gain in weak base capacity, decrease in water content and quantities of the composition products in the leach. The resin is found to be more resistant than Deacidite-FF to irradiation. (auth)

**28046** (NASA-SP-41(p.101-4)) SPECIAL TOPICS. C. RADIATION EFFECTS. Leo F. Epstein (General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.).

The possible effects of radiation on the corrosion characteristics of liquid metals are discussed. Enhancement of corrosion by radiation would be expected to occur for solution-controlled but not for diffusion-controlled corrosion. No experimental evidence for such effects have been collected. It is suggested, however, that the effects may show up in fast liquid-metal-cooled reactors. (D.L.C.)

**28047** (NP-13725) THE EFFECTS OF RADIATION ON EQUIPMENT AND COMPONENTS. L. Svansson and J. Danneels (European Company for the Chemical Processing of Irradiated Fuels, Mol, Belgium). Jan. 1963. 18p. (ETR-151)

Most of the experimental data on the effect of radiation on equipment and components are available from reactor experiments and concern only neutron radiation. As the effects of gamma and beta radiation are of most interest, efforts have been made to collect and summarize as much data as possible from available reports and articles concerning these radiations. The report is therefore specially intended to be a guide for the instrument engineer who has to design or select instruments or monitors for use in high gamma and beta radiation fields. (auth)

**28048** (NP-13980) EFFECT OF NUCLEAR RADIATION ON MATERIALS AT CRYOGENIC TEMPERATURES. Quarterly Progress Report No. 12, October 1963–December 1963. (Lockheed Nuclear Products, Marietta, Ga.). Contract NASw-114. 40p. (ER-6793)

Failure of nuclear instrumentation in test loops was investigated. Temperature correlation measurements were obtained from an instrumented titanium test specimen. Erratic behavior of the refrigeration system expansion engines is being evaluated. A Mallory 1000 shield stud and plug were successfully modified by remote handling techniques. Modification to test loop carriages continued. A chevron seal made of polyurethane was conceived, designed, and fabricated for the beam port. Flux measurements were made in a reactor beam port at varying reactor operating conditions and different rod positions to better evaluate the time required to achieve an integrated dose of $1 \times 10^{17}$ nvt fast neutrons (> 0.5 Mev) for in-pile tests. Both in-pile and out-of-pile test data were obtained on several materials during the period. (auth)

**28049** (ORNL-3635) PARAMAGNETIC CENTERS IN GERMANIUM DIOXIDE GLASS PRODUCED BY ELECTRON AND GAMMA-RAY IRRADIATION (thesis). Terry Purcell (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 76p.

Submitted to Vanderbilt Univ.

Paramagnetic centers produced in germanium dioxide glass by cesium-137 gamma rays and 1.5-Mev electron irradiations at room temperature were observed by electron spin resonance techniques at ~78°K. The most intense line observed in both gamma and electron irradiations had a line shape characteristic of powder patterns for axially symmetric g-tensors. Assuming this to be the case in the $GeO_2$ glass, g-values of $g_\perp = 1.9957$ and $g_{||} = 2.0016$ were fitted to the line which was 13 oersteds in width. The spin concentration of this line was measured as a function of increasing dose for both electron and gamma ray irradiations. The maximum concentration resulting from electron irradiation was approximately $2.5 \times 10^{18}$ centers/$cm^3$. On the basis of optical properties, the high spin concentration, and the estimated impurity content, it was assumed that this center was intrinsic to the $GeO_2$ glass. Similarities of this center to an intrinsic center, $E_1'$, observed in silica, are discussed. A tentative model for the paramagnetic center in the $GeO_2$ glass is that of an electron trapped in an uncompleted germanium bonding orbital. Powdered crystals of the hexagonal and tetragonal phase were also irradiated under similar conditions. The similarity of the line shapes in the powdered crystals of the hexagonal phase and in the glass was interpreted as indicating that the randomly oriented $GeO_4$ tetragonal groups of the glass bore some relation to the hexagonal phase of the crystalline material. Annealing of the electron irradiated glass produced another center similar to the one observed after irradiation. $g_{||}$ for these two centers was approximately the free electron's g-value; however, $g_\perp$ of the center produced by annealing was 2.0084. Other centers were also observed in the $GeO_2$ glass. (auth)

**28050** (TID-20671) RELEASE OF FISSION GAS DURING FISSIONING OF $UO_2$. R. M. Carroll, R. B. Perez, and O. Sisman (Oak Ridge National Lab., Tenn.). [1964]. Contract W-7405-eng-26. 28p.

A theoretical model is developed to explain mechanisms of fission-gas release from unclad ceramic fuels in high-temperature gas-cooled reactors. Experimental observations of $UO_2$ single crystals (TID-20672) were made and related to the model. (R.E.U.)

**28051** (TID-20672) IN-PILE FISSION-GAS RELEASE FROM SINGLE-CRYSTAL $UO_2$. R. M. Carroll and O. Sisman (Oak Ridge National Lab., Tenn.). [1964]. Contract W-7405-eng-26. 50p.

The fission-gas release from single-crystal $UO_2$ was studied during irradiation at temperatures from 400 to 1300°C and neutron fluxes from $1 \times 10^{13}$ to $4 \times 10^{13}$. The fractional gas release (rate of release/rate of production) was found to decrease with burnup and with increase in fission rate. Fission-gas release was independent of temperature below 600°C but increased exponentially with higher temperatures. From the proportions of different isotopes in the fission gas, it was concluded that a knock-out process controlled the low temperature gas release. The high temperature release, once thought to be by diffusion, is now postulated to be controlled by a trapping mechanism. (auth)

**28052** (WAPD-T-1574) THE EFFECTS OF IRRADIATION AT ELEVATED TEMPERATURES ON THE MECHANICAL PROPERTIES OF A TYPE 347 STAINLESS STEEL PRESSURE TUBE. F. R. Shober, W. E. Murr (Battelle Memorial Inst., Columbus, Ohio); and C. D. Sellers (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). June 1963. Contracts AT-11-1-GEN-14 and W-7405-eng-92. 25p.

Pressure tubes of type 347 stainless steel were irradiated in the ETR as the inner pressurized tube (temperatures up to 710°C) and outer gas jacket (180°C) of a pressure test loop. The maximum fast neutron flux dose was $7.1 \times 10^{21}$ nvt. The measured mechanical properties of the tubes showed large changes from the nonirradiated values for both tubes, but the tubes irradiated at the higher temperatures had the greatest changes. Some possible reasons for this unexpected result are discussed. (D.L.C.)

**28053** ELECTRIFICATION OF POLYSTYRENE PREVIOUSLY SUBJECTED TO THE ACTION OF GAMMA RADIATION. Georges Asch, Marie-Claude Félix, and Roger Ongaro (Université, Lyon). Compt. Rend., 258: 3982-5 (Apr. 20, 1964). (In French)

Charges are produced in polystyrene under gamma irradiation. The polarization resulting from the subsequent action of an electric field on the sample was studied. The results can be interpreted by the phenomenologic theory proposed by Kallman. (D.C.W.)

**28054** PEAKS OF INTERNAL FRICTION DUE TO POINT DEFECTS IN IRON IRRADIATED WITH NEUTRONS AT 78°K. Daniel Dauterppe, Vital Hivert, Pierre Moser, and Antoine Salvi (CEN, Grenoble, France). Compt. Rend., 258: 4539-41(May 4, 1964). (In French)

The internal friction of samples of pure iron were measured as a function of temperature after neutron irradiation at 78°K. Four peaks were observed, the annealing of which was studied. The effect of dosage on the height of the peaks was also investigated. A model is proposed for the defects responsible for the peaks. (D.C.W.)

**28055** AN EXPERIMENTAL STUDY ON THE PHOTOELECTRIC EFFECT INDUCED BY X-RAY. Shoichi Takekawa (Hirosaki Univ., Japan). Hirosaki Igaku, 15: 363-7(Oct. 25, 1963). (In Japanese)

Preliminary experiments to measure the sensitivity of ordinary phototubes to x rays, using the direct current amplifier, are reported. Two vacuum phototubes with Ag–Cs or Sb–Cs photoelectric surface were examined. They were sensitive when the x-ray tube was operated at voltages beyond 45,000 v. The Ag–Cs phototube was more sensitive than the Sb–Cs phototube. When the x-ray tube was operated at 65,000 v and 3 ma, the sensitivity of Ag–Cs tube to x rays was 30 μa after direct current amplification at the distance of 40 cm between the focus and the photoelectric surface, while the sensitivity of Sb–Cs phototube was 21 μa at twice the amplification. It was concluded that further studies are required because the sensitivity of photoelectric layers of ordinary phototubes is too low to use these materials for making a direct pick-up x-ray television camera. (TCO)

**28056** MODEL FOR FISSION-FRAGMENT DAMAGE IN THIN POLYCRYSTALLINE METAL FILMS. Allen N. Goland and Arthur Paskin (Army Materials Research Agency, Watertown, Mass. and Brookhaven National Lab., Upton, N. Y.). J. Appl. Phys., 35: 2188-94(July 1964). (BNL-7374)

Fission fragments produce tracks in thin films made up of small crystallites and do not produce tracks in continuous films. This has been difficult to understand on the basis of the spike models where only the energy transmitted directly to the lattice is considered and the energy acquired by the electrons is neglected. The energy to evaporate the crystallites must come from the electron gas because it has acquired almost all the energy initially lost by the fission fragment; consequently, in order to explain the evaporation of particles the subsequent electron energy-transfer processes must be understood. Examining

the various relaxation times, it is found that the energy is transferred first to other electrons via electron–electron collisions. If the electron gas is confined to a small region, as in a film of small crystallites, this immediately leads to a size effect. The largest crystallite that can be evaporated is one in which the total energy of the electron gas just equals the energy required for evaporation. This size estimate is an upper limit because the electrons may simultaneously lose energy via thermionic emission. A comparison of the two rate processes for an isolated particle of a typical metal suggests that electron–phonon energy transfer is the more important process, and that a negligible amount of energy is lost to the environment via escaping electrons. Consequently, almost all of the fission-fragment energy ultimately appears in the lattice. Estimates of the critical size for Au yield a diameter of about 170 Å for a spherical crystallite, in reasonable agreement with experiment. It is concluded that thin metal films will exhibit evaporation fission tracks provided that the film is made up of crystallites in poor electrical contact with one another and that the crystallites are smaller than the largest that can be evaporated. (auth)

**28057** PRIMARY DAMAGE STATE IN NEUTRON-IRRADIATED IRON. J. R. Beeler, Jr. (General Electric Co., Cincinnati). J. Appl. Phys., 35: 2226-36(July 1964).

An attempt was made to characterize the primary damage state produced in finite bcc iron samples by neutron irradiation at 0°K, in a series of computer studies. Distributed neutron spectra appropriate to graphite-moderated reactors, water-moderated reactors, and fission neutrons, together with monoenergetic neutron sources with energies up to 10 Mev, were used. The number of primary knock-on atoms displaced by neutron collisions and their energy spectrum were computed using the Monte Carlo method. Anisotropic neutron scattering as a function of energy was described using tabulated experimental data. Damage states produced by these primary knock-on atoms, as a function of their energy, were computed by tracing out elastic atomic collision cascades in the bcc iron lattice. A damage state was described in terms of the displacement spike volume distribution produced, the total number of displaced atoms, and the size distribution of vacancy and interstitial atom clusters in a displacement spike. A description of how the damage state depends upon sample geometry and shape, the incident neutron energy spectrum, and the incident neutron angular distribution is given. It is shown that the damage state produced in samples of different size and shape can be significantly different and the irradiation conditions required to produce equivalent damage states in different sample sizes are defined. The principal content pertains to the primary basis for the change in mechanical properties caused by neutron irradiation, as indicated by current theories. (auth)

**28058** EFFECTS OF IMPURITIES ON RADIATION DAMAGE OF SILICON SOLAR CELLS. Joseph Mandelkorn, Lawrence Schwarz, Jacob Broder, Harold Kautz, and Robert Ulman (Lewis Research Center, Cleveland). J. Appl. Phys., 35: 2258-60(July 1964).

Solar cells were made from silicon ingots containing either boron, aluminum, indium, gallium, or gadolinium as acceptors to test the hypothesis that the probability of a donor or acceptor atom associating with a lattice defect in silicon to create a recombination center is determined by the properties and concentration of donor or acceptor atoms and the density of lattice defects. The cells were subjected to 1-Mev electrons and 10-Mev protons, and their junction characteristic, diffusion length, and power output were measured. (R.E.U.)

**28059** THERMAL CONDUCTIVITY OF IRRADIATED SEMICONDUCTORS. J. K. D. Verma (Saha Inst. of Nuclear Physics, Calcutta). J. Inst. Telecommun. Engrs., 9: 262-7(1963).

The knowledge of thermal conductivity in semiconductors in relation to radiation damage effects is discussed. A thermal conductivity apparatus based on the non-equilibrium method is described in detail. For keeping the heat losses at a minimum, the relation between the radius and the thickness in case of a disc sample is given. The use of a comparator circuit for the measurement of small temperature differences, conducting the experiment in vacuum of the order of $10^{-3}$ mm of Hg are some refinements of the method. (auth)

**28060** OBTENTION OF ELONGATED DISLOCATION LOOPS, AND OF BUBBLES OF ARGON BY IRRADIATION OF Au SINGLE CRYSTALS WITH IONS. Bernard Jouffrey (Faculté des Sciences, Orsay, France). J. Microscopie, 2: 45-56(1963). (In French)

The effects of ion bombardments on thin evaporated crystals of gold were investigated by means of the electron microscope. At room temperature, elongated loops were observed if the ionic charge on the sample was large enough. The behavior of the defects during annealing showed that the elongated loops are dipoles. After a bombardment at 200°C new defects, which appear to be Ar bubbles, were observed. It is possible to observe the condensation of bubbles onto the dislocation loops. (auth)

**28061** EFFECT OF POST-IRRADIATION HEAT TREATMENT ON THE ELEVATED TEMPERATURE EMBRITTLEMENT OF IRRADIATED STAINLESS STEEL. W. R. Martin and J. R. Weir (Oak Ridge National Lab., Tenn.). Nature, 202: 997(June 6, 1964).

An investigation was made to determine the annealing characteristics of the elevated-temperature ductility effect of stainless steel. Tensile samples of type 304 stainless steel were irradiated at 290 and 550°C to $7 \times 10^{20}$ neutrons/cm$^2$ and an equivalent thermal flux. Some of the samples were then heat treated for one hr at 982°C before testing at 20 and 843°C. The results showed that the elevated-temperature embrittlement due to the irradiation was increased by annealing, and the low-temperature radiation effect tended to be removed by the annealing. (P.C.H.)

**28062** DUAL ROLE OF BORON IN THE ELEVATED TEMPERATURE EMBRITTLEMENT OF IRRADIATED COMPLEX HEAT-RESISTANT ALLOYS. J. Moteff, F. D. Kingsbury, and A. J. Lovell (General Electric Co., Cincinnati). Nature, 202: 997-8(June 6, 1964).

An investigation was made on the role of B in the elevated-temperature embrittlement of irradiated specimens fabricated from split heats of an Fe-base precipitation hardening alloy containing different amounts of natural B. There was little difference in the time to rupture for two unirradiated test specimens. The irradiated specimen containing the least amount of B showed about a factor of 6 reduction in the time to rupture and more significantly the specimen containing the greater amount of B ruptured within 25% of the corresponding unirradiated specimen. Although the irradiation seriously reduced the time to rupture only of the specimens containing the least amount of B irradiated specimens from both heats, however, did show significant reductions in the elongation and reduction-of-area parameters. In addition, the specimens containing the larger amount of B still exhibit slightly greater ductility than the specimens containing the least amount of B. (P.C.H.)

**28063** POINT DEFECT STUDIES IN GOLD BY ELECTRON IRRADIATION AT LOW TEMPERATURES. I. THRESHOLD DISPLACEMENT ENERGY AND DISPLACEMENT CROSS SECTION. Walter Bauer and A. Sosin (Atomics International, Canoga Park, Calif.). Phys. Rev., 135: A521-6(July 20, 1964).

The damage production on 99.999% pure 0.00025-in.-thick gold foils was measured as a function of incident electron energy in the range from 1.3 to 2.2 Mev. The effective threshold displacement energy was measured to be near 35 ev. It was found that reasonable agreement between the experimental and theoretical values of the displacement cross section could only be achieved with an unusually low value of the resistivity of a Frenkel pair ($\rho_F = 0.89 \times 10^{-4}$ Ω-cm/unit fractional concentration). By comparison, in copper the agreement between the theoretical and experimental cross section ($\rho_F = 1.2 \times 10^{-4}$ Ω-cm/unit fractional concentration) is somewhat better. This is interpreted to indicate that directional effects in the displacement process are considerably more important in gold than in copper, and that, for energies near the threshold energy, displacements in gold are possible only in a small solid angle centered about one crystallographic direction, most likely the ⟨100⟩ direction. (auth)

**28064** METHOD OF PREPARING LARGE-DIMENSION BETA IRRADIATORS. M. P. Kochina, I. A. Uryaev, and R. F. Brigevich. Radiokhimiya, 6: 255-8(1964). (In Russian)

Sources of $^{35}S$, $^{32}P$, $^{90}Y$, $^{185}W$, and $^{204}Tl$ were prepared, which had surface areas of 300 to 400 sq cm. In the method used, compounds of the elements were precipitated onto surfaces used as backings in the presence of surface-active compounds, e.g., isopropylene–naphthalene sulfonic acid. The active material was homogeneously distributed on the surfaces. The deposited crystals had diameters of 0.002 to 0.04 mm. The number of initial centers of crystallization was increased by lightly tarnishing the surface of the backing and lightly rubbing it with an inactive powder of the salt under study before applying the radioactive material. The compounds used were: for sulfur, $Na_2S$; phosphorus, $NaH_2PO_4$; yttrium, $Y_2O_3$; tungsten, $Na_2WO_4$; and thallium, $Tl(NO_3)_3$. The distribution of the radioactive material on the surface of the source depended on the shape of the backing, which indicated that sources of any given configuration may be obtained. Graphs are shown of the activities of the cross sections of prepared sources; the plateaus of the graphs show clearly the homogeneity of the preparations. (TTT)

**28065** EQUIPMENT FOR MAKING THIN, HOMOGENEOUS RADIOACTIVE SOURCES WITH LARGE SURFACES. L. Z. Malkin, I. D. Alkhazov, and A. M. Sokolov. Radiokhimiya, 6: 258-9(1964). (In Russian)

Equipment for capillary spraying of radioactive materials onto a backing is described. By means of this apparatus, radioactive sources of 8 cm diameter and larger were prepared. The radioactive layer was homogeneous. The equipment consisted of a platform with reciprocating motion and a stage that turns around an axis, which is fixed to the platform. Above the stage, held by a special clamp, is a capillary, which can be moved vertically by means of a screw. The platform is set in motion with an electric motor. It moves in a curved pattern, gradually covering the whole surface of the disk backing. A complete motion of the mechanism occurs in 17 seconds. The stage is also moved electrically. The diameter of the surface sprayed can be adjusted. A diagram of the equipment is shown (schematic) together with a drawing showing the curved pattern in which the radioactive material is laid down. (TTT)

**28066** A STUDY OF THE EFFECT OF NEUTRON IRRADIATION ON THE HARDNESS AND THERMOELECTROMOTIVE FORCE OF SOME METALS. S. D. Gertsriken, N. P. Plotnikova, I. F. Barchuk, Chia-k'un Liu. Sb. Nauchn. Tr. Inst. Metallofiz., Akad. Nauk Ukr. SSR, No. 17, 78-82(1963).

Investigations were made on the hardness and thermoelectromotive force of several technically pure metals with varying crystal structure (electrolytic Cu and Ni, Armco iron, Cr, Nb, and Mo) following exposure to neutrons at a maximum neutron density of $10^{14}$n/cm$^2$/sec. The hardness of annealed and irradiated samples was measured with a type TK Rockwell apparatus especially adapted for work in a hot chamber. The results showed the greatest increase in hardness in Cu and Ni, i.e., in metals with tightly packed body-centered lattices. The hardness of Fe increased considerably (a metal with a relatively low melting point); that of Nb (high melting point) showed hardly any change. In all cases, with the exception of Nb, the increase in hardness appeared only after a total dose of $10^{19}$n/cm$^2$. The effect of exposure to neutrons on the thermoelectromotive force of Mo and Nb was determined by the potentiometric method. A dose of $10^{17}$n/cm$^2$ yielded a thermoelectromotive force of $10^{-8}$ v/degree. Comparison of this value with the values obtained following maximal torsion or rolling deformation ($10^{-7}$ v/degree) showed that the effect of neutron irradiation was lower by one order of magnitude. Judging by the results obtained, it was assumed that the thermoelectromotive force increases with an increase in dose. It should be noted that the effect on the thermoelectromotive force appeared at lower total doses of exposure than the effect on hardness. (TCO)

**28067** RADIATION EFFECTS ON TEFLON AND TEFLON-BASED MATERIALS AT LIQUID-HYDROGEN TEMPERATURES. W. Weleff (Aerojet-General Nucleonics, Azusa, Calif.). Trans. Am. Nucl. Soc., 7: 67-8 (June 1964).

**28068** THE FORMATION AND RELEASE OF HELIUM FROM $UO_2$ FUEL DURING IRRADIATION. R. N. Duncan, C. J. Kubit, D. R. McClintock, and W. R. Smalley (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 89-90(June 1964).

**28069** FISSION-GAS RELEASE FROM $UO_2$ PELLET FUEL RODS WITH GROSS CENTRAL MELTING. R. C. Nelson, D. H. Coplin, M. F. Lyons, and B. Weidenbaum (General Electric Co., Pleasanton, Calif.). Trans. Am. Nucl. Soc., 7: 91(June 1964).

**28070** RELEASE OF FISSION PRODUCTS ON IN-PILE MELTING OF REACTOR FUELS UNDER TRANSIENT REACTOR CONDITIONS. G. W. Parker, R. A. Lorenz, and C. E. Miller, Jr. (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 92(June 1964).

**28071** $UO_2$ PELLET THERMAL CONDUCTIVITY FROM IRRADIATIONS WITH CENTRAL MELTING. M. F. Lyons, D. H. Coplin, T. J. Pashos, and B. Weidenbaum (General Electric Co., San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 106-7(June 1964).

**28072** IMPACT, MAGNETIC, AND RESONANCE PROPERTIES OF IRRADIATED SA212B PRESSURE-VESSEL STEEL. N. Balai (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 116-17(June 1964).

**28073** EVALUATION OF MILD STEEL IN THE HEAVY WATER COMPONENTS TEST REACTOR.

J. Malvyn McKibben (E. I. du Pont de Nemours & Co., Aiken, S. C.). Trans. Am. Nucl. Soc., 7: 121(June 1964).

**28074** A METHOD OF CORRELATING NEUTRON EXPOSURE FOR RADIATION-DAMAGE STUDIES. R. E. Dahl and H. H. Yoshikawa (General Electric Co., Richland, Wash.). Trans. Am. Nucl. Soc., 7: 125-6(June 1964).

**28075** IRRADIATION EFFECTS IN AUSTENITIC STEELS AND NICKEL-BASE ALLOYS. D. R. Harries and P. C. L. Pfeil (United Kingdom Atomic Energy Authority, Harwell, Berks, Eng.). Trans. Am. Nucl. Soc., 7: 126(June 1964).

**28076** POSTIRRADIATION ANNEALING OF SOME ALUMINUM-BASE FUELS. Charles F. Reinke (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 126-7 (June 1964).

**28077** WORK HARDENING OF NEUTRON-IRRADIATED COPPER SINGLE CRYSTALS. III. INTERPRETATION AND EVALUATION OF SOME WORK HARDENING PARAMETERS. Armin Rukwied and Joerg Diehl (Max-Planck-Institut fur Metallforschung, Stuttgart). Z. Metallk., 55: 266-76(May 1964). (In German)

Some parameters of work-hardening curves of neutron-irradiated copper single crystals were analyzed on the basis of Seeger's theory of irradiation hardening. According to Seeger, the critical shear stress $\tau_0$ is determined by the cutting of the moving dislocations through "depleted zones," formed during neutron irradiation, by means of stress-aided thermal activation. At low irradiation doses $\tau_0$ increased proportionally to the square root of the irradiation dose in full agreement with theory. Deviations from this law at high doses could be accounted for by radiation annealing due to the interaction of newly formed defects with already existing zones. The activation energy for cutting the zones by the dislocations and the effective zone diameter were determined from the dependence of $\tau_0$ on temperature and strain rate. The appearance of a yield phenomenon and the increase of the length of the yield point elongation zone with increasing irradiation dose and decreasing deformation temperature is explained by a destruction of the depleted zones during deformation. This causes a decrease of the contribution $\tau_S$ to the flow stress, which is due to the zones, and a negative slope of the local stress strain curve at the beginning of deformation. The decrease of the work-hardening coefficient in a certain stage of one type of curves with increasing dose is also explained by the decrease of $\tau_S$ which is, however, overcompensated in another stage by the increase of the contribution to the flow stress $\tau_G$, caused by the elastic interaction between dislocations. The rate of zone destruction $(-d\tau_S/da)$ appeared to depend on the deformation temperature. It was assumed, based on observations, that zone destruction influences the work-hardening coefficients of other types of curves as well. Another stage in the curves remained unchanged, and it showed the same temperature and strain rate dependence as in unirradiated crystals. It was concluded that this stage is initiated by cross slip in the same way as in unirradiated crystals. The activation energy again appeared to depend logarithmically on the stress, as in unirradiated crystals, but some of the characteristic parameters of cross slip, which were determined quantitatively, were different. (auth)

**28078** ELECTRON SPIN RESONANCE STUDIES OF IRRADIATED ALUMINUM OXIDE. Francis Trevor Gamble. Thesis, Storrs, Conn., Univ. of Connecticut, 1963. 122p.

Electron spin resonance investigations of aluminum oxide single crystals, irradiated by gamma rays, reactor neutrons, and energetic electrons, are reported, together with a tentative identification of several of the radiation-induced paramagnetic centers. Gamma rays produce a single, isotropic resonance line at g = 2.008 ± 0.002 which saturates in growth at 77°K with ~$3.10^4$ r. The line is attributed to holes trapped at naturally-occurring aluminum vacancies. Reactor irradiation produces a single, isotropic resonance line at 2.008 ± 0.002, which is attributed to a superposition of resonance lines that include the gamma-induced resonance line and resonances due to $Al^0$ atoms that have been displaced to natural voids in the $Al_2O_3$ lattice. In addition, reactor irradiation produces a system of twelve lines that is tentatively identified as the fine structure of neutral oxygen (S' = 1) in six inequivalent sites. The magnetic z axes of these sites lie in the (001) plane and make angles of about ±3° with the 0-0 directions of the $Al_2O_3$ molecules. The spin-Hamiltonian parameters assigned are $g_{||}$ = 2.0105 ± 0.0020, $g_{\perp}$ = 2.0190 ± 0.0020, D = 2.1284 ± 0.0020 kMc/sec, and E ≃ 0.075 ± 0.003 kMc/sec. Exposure of reactor-irradiated $Al_2O_3$ to gamma rays at 77°K produces a three-line fine structure, which is stable below 160°K. These lines saturate in growth with ~$1.2 \times 10^6$ r at an intensity that increases with reactor dose. The magnetic z axis of the paramagnetic center is parallel to the crystal c axis. The spin-Hamiltonian parameters assigned are $g_{||}$ = 2.001 ± 0.002, $g_{\perp}$ = 2.018 ± 0.002 and D = −1.12 ± 0.002 kMc/sec. The spectrum is attributed to $O^+$ ions that result from the ionization of $O^0$ atoms that have been displaced to natural voids during reactor irradiation. 1- and 2-Mev electron bombardment at 77°K also produces the three-line fine structure. In addition, a twelve-line fine structure is produced that is similar to the reactor-induced twelve-line system but which is characterized by a strong rhombic crystal field and a greater zero-field splitting. The magnetic z axes of these sites also lie in the (001) plane and make angles of about ±3° with the 0-0 directions of the $Al_2O_3$ molecules. The spin-Hamiltonian parameters assigned are $g_x$ = 2.0132 ± 0.0030, $g_y$ = 2.0182 ± 0.002, $g_z$ = 2.0148 ± 0.0020, D = 3.4430 ± 0.0020 kMc/sec, and E = 0.865 ± 0.005 kMc/sec. This spectrum is also tentatively identified as neutral oxygen in six inequivalent sites but with a different model describing the local environment of the oxygen. Additional paramagnetic centers are noted briefly. The ESR investigations utilized a superheterodyne microwave spectrometer operating at ~9200 Mc/sec and were made at room temperature, 77°K, 4.2°K, and at temperatures between 77°K and room temperature using a variable temperature microwave cavity, which is described in some detail. (Dissertation Abstr., 24: No. 11, 1964)

**28079** EFFECT OF NUCLEAR RADIATION ON TENSILE PROPERTIES OF HIGH-STRENGTH MATERIALS AT 20 K. AND 294 K. J. F. Watson, J. L. Christian, and J. W. Allen. p.52-73 of "Symposium on Materials for Aircraft, Missiles, and Space Vehicles." Philadelphia, American Society for Testing and Materials, 1963.

To study the nature of these effects, specimens were exposed to an integrated, fast neutron flux of about $2 \times 10^{17}$ nvt while being soaked in liquid hydrogen. After radiation exposure, the specimens were subjected to tension tests while being held at 20°K without intervening warmup. The alloys studied were types 301 and 310 stainless steels cold rolled 60 and 75% respectively, 5Al-2.5Sn titanium (A110AT), and 2014-T6 aluminum. The tension tests performed gave yield strength, tensile strength, elongation,

notched tensile strength ($K_t = 6.3$), and the tensile strength of simple heliarc butt-welded joints. Specimens were tested in the unirradiated and irradiated conditions at both 294 and 20°K. (Rev. Metal Lit., 21: No. 5, May 1964)

**28080** RADIATION EFFECTS OF PROTONS AND ELECTRONS IN SILICON DIFFUSED-JUNCTION DETECTORS. F. E. Scott (TRW Space Technology Labs., Redondo Beach, Calif.). 27p. (CONF-182-20)

From the 9th Scintillation and Semiconductor Counter Symposium, Washington, D. C., Feb. 1964.

Diffused n-p silicon particle detectors were irradiated with 1-Mev electrons, and with 31-Mev and 8.2-Mev protons. The detector capacitance was observed to increase with electron irradiation and to decrease with proton irradiation. A physical interpretation is given in terms of defect energy levels known to be introduced in silicon by irradiation. Defect ionization states are taken to be characteristic of the space-charge region, rather than of bulk silicon. The relation to other studies of damage in semiconductor particle detectors is pointed out, considering differences in the types of detector and irradiations used. The significance of these results is discussed for detector applications where the damage threshold is exceeded. (auth)

# METEOROLOGY

**28081** (AHSB(RP)-R-42) METHODS OF ESTIMATION OF THE DISPERSION OF WINDBORNE MATERIAL AND DATA TO ASSIST IN THEIR APPLICATION. Pamela M. Bryant (United Kingdom Atomic Energy Authority. Authority Health and Safety Branch. Radiological Protection Div., Harwell, Berks, England). May 1964. 36p.

Methods are described for use in the estimation of the dispersion of windborne material released to atmosphere at ground level or from stacks of various heights. The methods take account of a number of practical situations including the dispersion resulting from short, prolonged, and continuous releases and the effect on the dispersion of downdraft, efflux velocity, buoyancy, elevation of the place of interest, and prevailing wind. To assist in the application of the methods, relevant quantitative data are provided graphically where possible and instructions are given to facilitate use of the graphs as ready-reckoners without reference to the detailed description. (auth)

**28082** D- AND F-REGION EFFECTS ON COSMIC RADIO NOISE ABSORPTION FOLLOWING NUCLEAR DETONATIONS. A. K. Saha and K. K. Mahajan (National Physical Lab., New Delhi, India). J. Atmospheric and Terrest. Phys., 26: 618-24(May 1964).

Available data on detonation effects on cosmic radio noise at 22.4 Mc/sec are summarized for Soviet nuclear detonations in the Novaya Zemlya area in 1962. Examples of D and F region effects on cosmic radio noise absorption at 22.4 Mc/sec, on low frequency atmospheric at 100 kc/sec, and on $f_0$ F2 values are given. (M.J.T.)

**28083** ON THE EQUATIONS GOVERNING DIFFUSION IN THE F2-LAYER. P. C. Kendall (The University, Sheffield, Eng.). J. Atmospheric and Terrest. Phys., 26: 624-6(May 1964).

An attempt is made to show that the assumption that ion velocity ($v_i$) equals electron velocity ($v_e$) was not made in previous work on the diffusion equation for the F2-region. It is demonstrated that $v_i \neq v_e$ and that ionospheric electric currents exist, caused by the components of the pressure gradient and the gravitational forces acting at right angles to a magnetic field line. (M.J.T.)

**28084** THE LATITUDE VARIATION OF HEIGHT GRADIENT IN THE E-REGION DRIFT SPEEDS. G. L. Narayana Rao and B. Ramachandra Rao (Andhra Univ., Waltair, India). J. Atmospheric and Terrest. Phys., 26: 628-9(May 1964).

Data taken from five stations by the spaced receiver method during IGY are used. Average values of drift speeds for representative heights of 100, 110, and 120 km and height gradients are presented for the five latitudes. (M.J.T.)

**28085** SOME CHARACTERISTICS OF SPORADIC-E LAYER AT LOW LATITUDES. P. Venkateswarlu and Satyanarayana Ramu (Sri Venkateswara Univ., Tirupati, India). J. Atmospheric and Terrest. Phys., 26: 629-31 (May 1964).

The fading characteristics of the echo from the $E_s$ layer formed at four different hours of the day were studied at Tirupati, India. Attempts were made to fit the observed amplitude distribution curves with Rayleigh, Gauss, and Rice functions. (M.J.T.)

**28086** AIR CHEMISTRY AND RADIOACTIVITY. Christian E. Junge. International Geophysics Series. Volume 4. New York, Academic Press, 1963. 391p. $13.50.

The constituents and chemical processes of the atmosphere below the mesopeak (below about 50 km) are discussed. All gaseous, particulate, and radioactive substances are included and the altitude range of the stratosphere and mesosphere that can be probed with balloons and high-altitude aircraft is covered. Topics discussed include: gases, aerosols, atmospheric radioactivity, chemistry of precipitation, and the role of air pollution in air chemistry. The literature is covered through 1960 and part of 1961. Author and subject indexes are included. (M.C.G.)

# PHYSICS

## General

*Refer also to abstract 27438.*

**28087** (HW-79280(p.10.1-9)) PHYSICS. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

PHYSICS: EBWR Design Studies. PRCF experiments and computer code calculations indicate that 1.5 wt % $PuO_2$-enriched $UO_2$ can be used instead of 2.5 wt % $PuO_2$ as was originally intended and that reduction in enrichment will not deter successful completion of the experimental program. (auth)

**28088** (HW-80284(p.10.1-28)) PHYSICS. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

A nuclear parameter survey for compact, fast-spectrum, cermet reactors is presented in connection with nuclear rocket programs and nuclear electric propulsion devices. A series of $S_4$ transport calculations were made for a variety of beryllium-reflected, cermet reactor cores. The cores were assumed to be spherical and consist only of fuel, diluent, and void. The void represents the coolant. $UO_2$, $PuO_2$, PuN fuel materials were considered, tungsten was the diluent, and reflector voids were considered. Reactor volumes and weights were plotted as a function of flow area. The second part of calculations of the scattering law for water is presented. (Part I is NSA 17: 31079). An exact treatment of two resonance levels is included retaining finite-width analytic functions for the spectral function. Areas of validity of the modified gas equation for graphite moderators were investigated by comparing its solution for the neutron flux distribution with the solution obtained from the balance equation. Uranium-graphite results were good, whereas plutonium–graphite results were inaccurate because of the 0.3-ev resonance of $^{239}Pu$. (R.E.U.)

**28089** (IMM-NYU-322) BENDING OF RECTANGULAR PLATES WITH FINITE DEFLECTIONS. Frances Bauer, Louis Bauer, William Becker, and Edward L. Reiss (New York Univ., New York. Courant Inst. of Mathematical Sciences). Apr. 1964. Contract AT(30-1)-1480 and Nonr-285(42). 26p.

A previously developed iterative procedure is applied to obtain numerical solutions of the von Kármán equations for rectangular plates subjected to a uniform normal pressure. On the simply supported boundary, it is assumed that the normal membrane stress and the tangential membrane displacement vanish. Solutions are obtained for a wide range of values of the loading parameter and the aspect ratio. Boundary layers develop both as the loading parameter and the aspect ratio increase. The stresses and deflections are examined and compared with an "asymptotic" solution that can be valid only in the interiors of long plates. A comparison is made with a previously obtained approximate solution by the Ritz method for the square plate. (auth)

**28090** (IS-863) PRELIMINARY STUDY OF THE OPTICAL CONSTANTS OF SILVER–CADMIUM ALLOYS NEAR 300 mμ. R. G. Dorothy and D. W. Lynch (Ames Lab., Ames, Iowa). May 1964. Contract W-7405-eng-82. 23p.

The room temperature optical constants of several silver–cadmium alloys (0 to 12.5% Cd) have been measured by Avery's method in the wavelength region 290 to 335 mμ. The observed changes of the real and imaginary parts of the dielectric constant, $\epsilon = \epsilon_1 + \epsilon_2$, and of the plasmon loss function, $-\mathrm{Im}\,(\epsilon^{-1})$, are interpreted qualitatively. The interband transition at ~3.9 ev has a state on the Fermi surface for its final state, in agreement with the assignment of Philipp and Ehrenreich. The shift in the plasma frequency upon alloying can be interpreted qualitatively as due to an increase in electron concentration, the interband contribution to the dielectric constant at the plasma frequency being roughly independent of alloying. The shortening of the relaxation time for plasmons upon alloying is evident. Quantitative interpretation requires better data, obtained with some degree of control over surface conditions, over a wider wavelength range than is studied here. (auth)

**28091** (ORNL-3630) ELECTRONUCLEAR DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING DECEMBER 31, 1963. (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 129p.

In heavy-ion nuclear physics studies, the nitrogen and oxygen beams of the 63-Inch Cyclotron and the Tandem Van de Graaff were used in investigations of statistical fluctuations in cross sections, of excitation functions and angular distributions for nucleon-transfer reactions, and of the spin-cutoff parameter from compound nucleus reactions. Improvements in instrumentation and computational techniques for the nuclear physics studies with protons revealed finer details in nuclear structure, for example in $^{92}Nb$, $^{89}Zr$, and neighboring nuclei, and produced much new information concerning levels of $^{190}Ir$. The theoretical physics group report a description of nuclear shell-model calculations, the results of a consideration of the $\Sigma^-$ interaction with $^4He$, and a continuation of investigations of the reactions between complex nuclei. The report of the accelerator development programs describes the successful operation of a new and very efficient system for extracting the beam in the Oak Ridge Isochronous Cyclotron, studies in support of the proposed 810-Mev $Mc^2$ Cyclotron, and exploratory studies to evaluate the potentialities of the Separated-Orbit Cyclotron. Separate abstracts were prepared for each of the 5 sections. (auth)

*For abstracts of individual papers see: 28188, 28189, 28573, 28574, and 28575.*

**28092** (SC-R-64-147) THE PROPAGATION OF TRANSIENT ELECTROMAGNETIC FIELDS INTO A CAVITY FORMED BY TWO IMPERFECTLY CONDUCTING SHEETS. C. W. Harrison, Jr., M. L. Houston (Sandia Corp., Albuquerque, N. Mex.); R. W. P. King, and Tai Tsun Wu (Harvard Univ., Cambridge, Mass.). Apr. 1964. Contract [AT(29-1)-789]. 39p.

Steady-state formulas are developed for the ratio of the resultant electromagnetic field in the screened space formed by dual, infinite, homogeneous metal plates to the incident field, and from these transfer functions the time history of the field in the cavity is computed for Gaussian-shaped input fields. (auth)

**28093** (SCDR-65-61) AN EXPLANATION OF THE INCONSISTENCY OF SPALLATION THRESHOLDS AS DETERMINED BY VARIOUS OBSERVERS. W. F. Hartman (Sandia Corp., Albuquerque, N. Mex.). Feb. 1961. Contract AT(29-1)-789. 7p.

Recent determinations at different laboratories of the minimum incident pressure required to cause a separated spall in copper yielded values of 25 to 75 kbar. The possible causes of the inconsistent data are discussed, with emphasis on differences in the experimental techniques. Elimination of the discrepancies is also considered. (D.C.W.)

**28094** (TID-20607) QUARTERLY PROGRESS REPORT NO. 73 [ON ELECTRONICS]. H. J. Zimmermann and G. G. Harvey (Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics). Apr. 15, 1964. Contract AT(30-1)-906. 262p.

Studies are reported of: the development of an ammonia maser with separated cavities; theory of cross relaxation in ruby; microwave properties of the atmosphere and surface of Venus; the design of a radiometer for the 19 to 26 Gc band; the dielectric properties of $BaTiO_3$ in the i-r region; production and properties of plasma; effects of probes on plasma; atomic spectroscopy of $^{199}Hg$ by level-crossing methods; properties of the atmospheric aerosol layer at 20 km; phenomena at the interface between a coronea discharge and a neutral gas; acoustic radiation from moving point multipoles; studies of shock structures; electrodynamics of moving polarizable media; anomalous cyclotron radiation from Xe and Kr plasma; confinement of ionic plasma with steady and fluctuating magnetic fields; effects of gas flow on plasma stability; cyclotron radiation from electron-beam-generated plasma; properties of electric-discharge plasma devices; oscillations and resonance discharges in plasma; wave propagation in hot-electron plasma; computer analysis of plasma wave instabilities; development of thermonuclear reactor blankets; MHD properties of plasma; MHD cell development; magnetic field effects on surface waves in incompressible, conducting fluid flow; effects of imperfections on hydromagnetic waveguide performance; friction factor measurements in liquid metal MHD channel flows; dipole-dipole interactions between polarizable particles and adsorbed layers of dipoles; communications (statistical theory, speech, linguistics, etc.); processing and transmission of information; communication biophysics, neurophysiology, and neurology; cognition; and artificial intelligence. (T.F.H.)

**28095** (TID-20669) NUCLEAR QUADRUPOLE COUPLING STUDIES IN SOLIDS. Annual Progress Report, May 1, 1963–May 15, 1964. (Rensselaer Polytechnic Inst., Troy, N. Y.). May 1964. Contract AT(30-1)-3030. 4p.

Work is continuing on the study of $^{27}Al$ quadrupole coupling in $AlI_3$. In the study of $^{23}Na$ quadrupole coupling in Rochelle salt, the nuclear magnetic resonance (NMR) spectrum at temperatures below the lower Curie point is similar to that above the upper Curie point, indicating identical crystal structures. The NMR also changes continuously with temperature and with no broadening in the vicinity of both Curie points. The splitting of the NMR of two different $^{23}Na$ nuclei in the unit cell in passing from the nonferroelectric to the ferroelectric region, was shown to be due to the polarization of the crystal. The $^{23}Na$ NMR in gamma-irradiated single crystals of sodium chlorate was studied and found to broaden and become less intense on irradiation, but the shortened relaxation time complicated the interpretation of the data. (D.L.C.)

**28096** (Y-1470-E) X-RAY FLUORESCENCE TABLES: GYPSUM CRYSTAL. W. P. Amsbury, W. W. Lee, J. H. Rowan, and G. E. Walden (Union Carbide Corp. Nuclear Div. Y-12 Plant, Oak Ridge, Tenn.). Apr. 24, 1964. Contract W-7405-eng-26. 187p.

A critical compilation of standard reference tables of x-ray fluorescence lines for a gypsum crystal is published in convenient form for experimental use. (auth)

**28097** RANGE OF ENERGETIC $Xe^{125}$ IONS IN MONOCRYSTALLINE SILICON. J. A. Davies, G. C. Ball, F. Brown, and B. Domeij (Chalk River Nuclear Labs., Chalk River, Ont., Can.). Can. J. Phys., 42: 1070-80 (June 1964).

An electrochemical "peeling" technique for dissolving thin (40–600 Å) uniform layers from the surface of a silicon crystal was developed and calibrated. Using this technique, range distributions of 5–80 kev $^{125}Xe$ ions in monocrystalline silicon were measured as a function of the crystallographic direction. The ranges were found to depend strongly on the initial direction of ion motion, with the observed order being: [110] ≫ [112] > [111] ≈ [100]. These results for a diamond-type lattice are in qualitative agreement with the recent computer studies of Robinson. Even for the least penetrating directions, the observed range is about three times the value expected in the absence of crystal lattice effects. At ion bombardments exceeding $10^{12}$ $Xe^+/cm^2$, the observed penetration decreased significantly; this sensitivity to rather low levels of ion bombardment suggests that bombardment induces a change in crystal structure. (auth)

**28098** EXPERIMENTAL EVIDENCE FOR THE CHANNELING OF HEAVY IONS IN MONOCRYSTALLINE ALUMINUM. G. R. Piercy, M. McCargo, F. Brown, and J. A. Davies (Chalk River Nuclear Labs., Chalk River, Ont., Can.). Can. J. Phys., 42: 1116-34(June 1964). (AECL-1954)

The penetration of radioactive $^{24}Na$, $^{85}Kr$, $^{86}Rb$, and $^{133}Xe$ ions with energies of 20 to 160 kev into oriented aluminum single crystals was measured using an anodic stripping technique. Many of the incident ions penetrated several times farther than normal when the ion beam was aligned with directions of closely packed atoms in the crystal lattice. Comparison with theory showed that these ions traveled down channels between the rows of closely packed aluminum ions. The penetration distance and fraction of incident ions traveling these channels increased successively for beams in the directions [111], [100], [112], and [110]. The energy and mass dependence of the penetration of these channeled ions indicates that an appreciable amount of their energy is lost by electron excitation. (auth)

**28099** EXCITATION OF $N_2$ BAND SYSTEMS IN AURORA. A. L. Broadfoot and D. M. Hunten (Univ. of Saskatchewan, Saskatoon, Can.). Can. J. Phys., 42: 1212-30 (June 1964).

The near-ultraviolet region of the auroral spectrum was observed by a photoelectric spectrometer for the purpose of deriving accurate relative intensities of the $N_2$ band systems. To increase the signal-to-noise ratio with the faint auroras measured, long "exposures" were accumulated in a memory unit. From the band intensities in the Vegard–Kaplan system, the relative populations of the first three vibrational levels of the metastable $A\ ^3\Sigma_u^+$ state were found; the ratios appear to vary significantly. These bands give a rotational temperature of 800 ± 200°K; they must therefore be emitted from a height of about 220 km. The vibrational populations are most reasonably explained if nearly all the excitation of the A state is by cascading from higher levels. A detailed discussion is given of these processes, supplemented by measurements of the second positive bands. Cascading is found to supply an appreciable fraction of the excitation of the $B^3\Pi_g$ state; the $C^3\Pi_u$ state seems to be excited purely by electron impact. Previous

evidence that the latter is not always true is examined and rejected. (auth)

**28100** ON THE TIME-DEPENDENT BOLTZMANN EQUATION FOR ELECTRONS AND PHONONS. S. Simons (Univ. of London). Can. J. Phys., 42: 1231-5(June 1964).

It is shown that the solution of the time-dependent Boltzmann equation for an arbitrary initial distribution tends to the stationary-state solution with the passage of time. The explicit time variation of the distribution is obtained in certain cases, and the significance of the results is discussed. (auth)

**28101** LE BOMBARDEMENT IONIQUE. THEORIES ET APPLICATIONS. COLLOQUES INTERNATIONAUX DU CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, NO. 113, BELLEVUE, 4-8 DECEMBRE 1962. (Ionic Bombardment. Theories and Applications. International Colloquium No. 113 of the National Center of Scientific Research, Bellevue, December 4-8, 1962). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 1-243(1962). Paris, Centre National de la Recherche Scientifique, 1962. 60 F.

The 25 papers presented at the 113th International Colloquium on ionic bombardment are compiled together with discussions following the presentations. Separate abstracts were prepared for all the papers. (J.S.R.)

*For abstracts of individual papers see: 28102, 28103, 28104, 28105, 28106, 28107, 28108, 28109, 28110, 28111, 28112, 28113, 28114, 28115, 28116, 28117, 28118, 28119, 28120, 28121, 28122, 28123, 28124, 28125, and 28126.*

**28102** IONIC BOMBARDMENT. NEW METHOD FOR THE STUDY OF SURFACES. Jean-Jacques Trillat (CNRS, Bellevue, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 13-34(1962). (In French)

The techniques used to produce well-defined ion beams in vacuum or air are illustrated by descriptions of the ion sources at the X-Ray Laboratory of the CNRS. The methods for the examination of the effect of ions on surfaces and the factors affecting the actions of ion bombardment are reported and discussed. The general physical and chemical effects and their applications are reviewed. The theories of ion bombardment are briefly summarized. (J.S.R.)

**28103** SOME PHYSICOCHEMICAL EFFECTS OF IONIC BOMBARDMENT OF CRYSTALLINE TARGETS. Walter J. Moore, Samuel R. Logan, Lars C. Luther, and Sylvester N. Brown (Indiana Univ., Bloomington). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 35-48(1962).

The studies made on the amount and distribution of dissolved He in bombarded metal targets and on the decomposition of films of crystalline nitrates by ionic bombardment are summarized. Typical helium evolution curves obtained from Al and Ag targets previously bombarded with He ions are given and their significance discussed. The decomposition of metal nitrate crystalline films by bombardment with $H^+$, $D^+$, $D_2^+$, and $He^+$ at kilovolt energies was investigated using $KNO_3$ targets primarily. The effects of dose rate, total dose, ion energy, and cation were determined, and the trial models to interpret these reactions are discussed. (J.S.R.)

**28104** SURFACE PHENOMENA RELATED WITH SPUTTERING. J. Kistemaker and C. Snoek (FOM, Laboratorium voor Massascheiding, Amsterdam). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 51-61 (1962).

The light emitted by Al and Cu targets (polycrystalline as well as monocrystalline Cu targets) under bombardment with 10 to 15 kev $Ne^+$ and $Ar^+$ was studied. The strong lines observed in the Cu I, Cu II, Ar II, and Ne II spectra are tabulated, and the intensity was determined as a function of the angle of incidence of the ion beam. The Ar I and Ne I spectra were not observed. The angular dependence measurements were used to determine the processes taking place at the surface and in the gas phase directly in front of the surface. The metastable Cu atoms leaving the surface under bombardment, announced previously, were shown to have an energy of several kev rather than 10 ev. On the basis of data obtained from the improved detector system, it could not be excluded that metastable atoms play a role in the phenomena observed. A very strong directional effect of the reflection was found. It was concluded that only quasi-elastic and inelastic collisions with lattice atoms play a significant role in the production of the spectra observed. (J.S.R.)

**28105** EFFECTS OF IONIC BOMBARDMENT OF SHORT DURATION ON METALLIC MONOCRYSTALS. R. Castaing and B. Jouffrey (Faculté des Sciences, Orsay, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 63-6(1962). (In French)

The technique of ionic sputtering for the preparation of electron microscopic samples often gives a very rough surface, especially in heavy metals. The origin of this roughness was studied on gold monocrystals with a thickness of 20 mμ. The gold was bombarded with Ar ions at 4000 ev for a duration of 0.1 to 2 sec. Two characteristic aspects are obtained under such conditions: a large number of small marks parallel to the 110 direction of the (001) plane and the dislocations preexisting in the gold layer seem to disappear and the faults introduced by bombardment appear. The evolution of this phenomenon was followed to determine the mechanism. (J.S.R.)

**28106** BOMBARDMENT OF A METALLIC TARGET BY MEDIUM-ENERGY IONS (10 TO 150 kev). CATHODIC PULVERIZATION AND SECONDARY EMISSION. Charles Fert, Nicole Colombie, Bernard Fagot, and Phan Van Chuong (Laboratoire d'Optique Electronique, Toulouse). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 67-76(1962). (In French)

The secondary emission and the cathodic pulverization of a metallic target by ions with energy from 10 to 150 kev were studied for a series of metals. A brief description is given of the experimental set-up, and the results are presented. The mechanism for the reaction of rapid ions and metallic targets is discussed in a general manner. The application to the problem of image contrast in an electron microscope with secondary emission under ion bombardment is discussed. (tr-auth)

**28107** CLEANING OF VERY OXIDIZABLE METALS BY IONIC BOMBARDMENT AT MEDIUM AND LOW ENERGIES IN A DIFFRACTOGRAPH. M. Gribi (Laboratoires Scientifiques de Trüb, Taüber et Cie, S. A., Zurich). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 77-82(1962). (In French)

An efficient method was developed to reduce the secondary oxidation in a vacuum of the order of $10^{-5}$ torr. The method consisted of ion bombardment in an enclosure cooled with liquid nitrogen to reduce the thermal energy of the residual oxygen. The apparatus used is described, and the results obtained on cleaning Al, Mg, and Gd are reported. These results show that such an enclosure is efficient under varied conditions. (J.S.R.)

**28108** ON THE PREPARATION OF METAL FOILS FOR IRRADIATION BY ION ETCHING. H. Dueker and W. Schlette (Max-Planck-Institut für Metallforschung, Stuttgart). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 83-90(1962). (In German)

The principle of the emission electron microscope, used for the study of the effects of ion bombardment on metal surfaces, is briefly discussed. The basic effects of ion bombardment are electron emission, chemical reactions, sample heating, and sample decomposition. This last effect was used to prepare samples for study in an emission electron microscope. Polycrystalline metal foils were so attenuated by ion etching that they were penetrable by 100 kev electrons. The results obtained on Al and Cu foils using xenon as the discharge gas are reported. The decomposition rate was dependent on the inclination of the ion beam to the surface and angle of the ion beam to the crystallographic orientation of the metal. (J.S.R.)

**28109** APPARATUS FOR STUDY OF THE HEATING OF METALS IN THE COURSE OF IONIC ATTACK. P. Haymann and H. Gervais (CNRS, Bellevue, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 91-4(1962). (In French)

An apparatus for the study of metals in a hot state during ion bombardment is described. The device maintains a vacuum of the order of $10^{-6}$ mm Hg, and the sample can be given any orientation during the bombardment. The sample can be heated to a temperature of 1500° and be turned at an angular velocity of 1 to 2 turns/sec. Observations may be made by an optical microscope in situ, which is mounted on a diffractometer allowing simultaneous diffraction. There is an easily controllable leak with which any gas may be introduced at the level of the sample. A current inlet is provided for the study of particular problems with semi-conductors. (J.S.R.)

**28110** THINNING DOWN BY IONIC BOMBARDMENT OF METALLIC SPECIMENS WITH A VIEW TO THEIR EXAMINATION WITH AN ELECTRON MICROSCOPE. COMPARISON FOR SOME ALLOYS WITH ELECTROLYTIC THINNING DOWN. B. Genty (O.N.E.R.A., Chatillon, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 95-104(1962). (In French)

Some general observations made during the use of ion bombardment for the preparation of metallic samples transparent to electrons are reported. The apparatus used and the experimental conditions are described. The dimensions of the observable regions, selective cleaning, behavior of the boundaries, and effect on dislocations were discussed generally. Ionic bombardment thinning down was compared with electrolytic thinning down for Co and Al–Zn samples. It was emphasized that no study was made of ionic bombardment itself, but its use to resolve problems in the transmission examination of metallic samples. It was concluded that ionic bombardment is a valid method for the preparation of transparent metallic samples for electron microscopy. Its advantages and disadvantages are indicated. (J.S.R.)

**28111** MONTE CARLO CALCULATIONS OF THE RANGES OF ENERGETIC ATOMS IN SOLIDS. Mark T. Robinson, D. K. Holmes, and O. S. Oen (Oak Ridge National Lab., Tenn.). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 105-17(1962).

The slowing down of energetic atoms in solids was investigated through the use of Monte Carlo methods on a large digital computer. Neither the hard sphere approximation nor the inverse square approximation affords a particularly satisfactory account of the exponentially screened Coulomb potential. It is found for Cu, Ag, and Au, slowing down in their respective solids, that the screening radii must be respectively 1.15, 1.6, and 2.3 times greater than the values proposed by Bohr, in order to explain the available experimental data. It is apparent from the results of these calculations that modifications of the interatomic potential functions must be sought, especially for heavier elements. (auth)

**28112** SPUTTERING OF COPPER SINGLE-CRYSTALS BY 20-kev NOBLE GAS ION BOMBARDMENT AS A FUNCTION OF TARGET TEMPERATURE AND AS A FUNCTION OF THE ANGLE OF INCIDENCE. J. M. Fluit (FOM, Laboratorium voor Massascheiding, Amsterdam). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 119-23 (1962).

The total sputtering of a (110) and a (111) Cu crystal by 20-kev $Ar^+$ ions was measured by the weighing method. There was a small decrease in sputtering for the (111) crystal and a small increase for the (110) crystal at lower target temperatures. The increase of damage at the crystal surface is because this damage is averaged over time. Total sputtering ratios of (100) and (110) copper crystals were measured on crystals turned around the (100) axis to vary the angle of incidence. The ratios were diagrammed for $Ar^+$ and $Ne^+$ incident ions. The beam maxima for the two ions are in beam directions where the crystal layer has its densest projection. Diameters were calculated as 0.70 A for Ar bombardment and 0.62 A for Ne bombardment. (J.S.R.)

**28113** THIN MONOCRYSTALS PRODUCED BY CATHODIC SPUTTERING. H. Raether (Universität, Hamburg). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 129-34(1962).

A résumé is given of the results of the study on the application of cathodic sputtering by Hietel and Meyerhoff (Z. Physik, 165: 47(1961)). The cathodic sputtering method was applied to the preparation of perfect monocrystalline films of small thickness. The results obtained with Si were quite good, but oxidation taking place on Al and Cu caused the results to be less good. Some preliminary results on the nature of the scattering process in the Kikuchi lines compared with that of a Laue spot are reported. (J.S.R.)

**28114** REALIZATION OF A GUN OF PROTONS OF FINE FOCALIZATION WITH A STABLE PLASMA SOURCE. Claude Magnan and Monique Fournier (Laboratoire de Synthese Atomique et d'Optique Protonique, Ivry-sur-Seine, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 135-42(1962). (In French)

The design and construction of a fine-focusing proton gun with a stable plasma source are described. The ion source, gun with enlarged and with reduced image, optics of the extraction channel, and structure of the beam are discussed. (J.S.R.)

**28115** PRODUCTION AND UTILIZATION OF ION BEAMS IN A PRIMARY VACUUM CHAMBER. N. Azam (CEN, Saclay, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 147-54(1962). (In French)

The principle, operation, construction, and characteristics of an ion source in a primary vacuum chamber are described. The gun itself is composed of a crossed anode and a grid cathode. The device is sturdy, simple to use, and has a complex beam. Samples of its use in cleaning and metallographic attack are given. (J.S.R.)

**28116** INTRODUCTION OF RARE GASES INTO METALS BY ELECTRIC DISCHARGE. G. Brebec,

V. Levy, J. Leteurtre, and Y. Adda (CEN, Saclay, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 155-64(1962). (In French)

The results obtained in the introduction of rare gases into metals by crossed cathode electric discharge are briefly summarized. A mechanism for the fixation of the rare gas based on a penetration of the rare gas atoms into the lattice combined with a redeposition of the metallic atoms released by cathodic attack is proposed. The method for rare gas introduction was improved so that the rare gas concentration was considerably increased, the gas had a uniform distribution on the cathode, and the concentration of the gas in redeposited zones can be varied. The silver cathode surfaces were examined by transmission electron microscopy and the results reported and discussed. (J.S.R.)

**28117** EXPERIMENTAL STUDY OF THE VARIATION OF THE RATE OF CATHODIC PULVERIZATION AS A FUNCTION OF THE TEMPERATURE OF THE TARGET. C. Cassignol (CEN, Saclay, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 165-72(1962). (In French)

An hypothesis is advanced to explain the disappearance of saturation, and preliminary results supporting this hypothesis are reported. A rough experiment to determine the variation of the rate of pulverization as a function of temperature with constant beam density is described. Precise results are not yet available because of experimental difficulties encountered. The use of an electromagnetic isotope separator in studies on ionic bombardment and the problems in its utilization are discussed. (J.S.R.)

**28118** ENERGY CHAIN EFFECTS IN THE SPUTTERING PROCESS. Don E. Harrison, Jr. (Univ. of Toledo). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 173-80(1962).

The statistical approach to sputtering theory has been useful in the past, but recently significant progress has resulted from the application of energy chain techniques to specific problems. Here we examine the compatibility of the two approaches, and determine that the chain mechanism actually strengthens the statistical model. The major feature of both approaches can be maintained if each is applied in the appropriate energy range. (auth)

**28119** LOW-ENERGY SPUTTERING STUDIES. G. K. Wehner (General Mills Electronics Group, Minneapolis). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 181-90(1962).

The results of a series of studies on sputtering of metals under rare gas ion bombardment are summarized. Sputtering yields are graphed as a function of atomic number of the target. The application of emission spectroscopy to the measurement of sputtering thresholds or yields at very low ion energy is discussed, and the principals of the method are given. The threshold energies for some metals are tabulated. The differences obtained in sputtering yields with variation of the angle of incidence of the ion beam are indicated briefly. (J.S.R.)

**28120** SOME ASPECTS OF THE PULVERIZATION OF COPPER BY MEDIUM-ENERGY PROTONS. M. Denoux (CNRS, Bellevue, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 191-8(1962). (In French)

The pulverization of Cu crystals by $H^+$ ions falling normal to the surface was studied for ion energies between 10 and 50 kev. The effects of crystal orientation, ion energy, and sample temperature on the coefficient of pulverization were determined and represented by numerical relations. The experimental technique to separate the thermal phenomena from those resulting from ionic bombardment was described. (J.S.R.)

**28121** ORIGIN OF EMISSION IN A METALLIC TARGET BOMBARDED BY POSITIVE IONS. R. Bernard, R. Goutte, C. Guillaud, and R. Javelas (Institut National des Sciences Appliquees, Lyon). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 199-204(1962). (In French)

It was previously shown that a metal exposed to positive ionic bombardment emits negative ions and that these ions can be used to form images of the metal surface. It was hopothesized that the negative ions come from adsorbed layers on the metal surface and are probably composed of water vapor and hydrocarbons. Experiments were carried out on Mo, Ni, Ag, and Be to test the hypothesis by modification of the primary bombardment, modification of target nature, elimination of occluded gases, heating of the target, and determination of the role of adsorbed layers. The experimental set-up is described, and the results are discussed. The results show that the negative ions came from physically or chemically adsorbed layers on the metal surface or result from the action of residual oxygen on the metal. (J.S.R.)

**28122** SELECTIVE ATTACK ON SILVER BY ARGON IONS OF WEAK ENERGY—STUDY OF PSEUDO-PERIODS. P. Haymann and C. Waldburger (CNRS, Bellevue, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 205-10(1962). (In French)

In addition to the appearance of facies geometric with respect to the orientation of the bombarded crystal (selective attack), the privileged directions (110) and (100) are found in the form of segments whose length varies with the orientation of the ions. This attack characteristic was studied and the mean length of the segments having the same direction, called pseudo-period, was calculated. The experimental conditions and the errors in measurement are discussed. The Ag monocrystals were bombarded with Ar ions at 8 kev with a flux of 1 $\mu amp/mm^2$. The results are given and discussed. An hypothesis to explain the physical process for the formation of the segments is proposed. (J.S.R.)

**28123** STUDY OF THE EFFECTS OF PREVIOUS IONIC BOMBARDMENT ON OXIDATION OF COPPER AT LOW OXYGEN PRESSURES. E. D. Hondros and J. Benard (Ecole Nationale Superieure de Chimie, Paris). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 211-20(1962). (In French)

The effects of a preliminary ionic bombardment on the oxidation of monocrystalline Cu at low oxygen pressures were studied under conditions similar to those under which the formation of oxide germs was studied. The experimental method is described. The effects of bombardment on the surface of the Cu and its oxidation processes were determined. The structure of the oxide films formed on polished and bombarded surfaces was studied by electron microscopy. The results were given and discussed. (J.S.R.)

**28124** ON THE PECULIARITIES OF THE ANISOTROPY OF THE MONOCRYSTAL CATHODE SPUTTERING. V. E. Yurasova, I. G. Sirotenko, and V. M. Buhanov (Mos-

cow State Univ.). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 221(1962).

A study was made of the directed emission of particles from sputtering of Cu, W, Fe, Co, Cr, Ge, Si, and InSb single crystals as a function of temperature, crystal characteristics, atomic number, and sputtering ratio. It was established that Kr ion sputtering at 10 kev on metals with an fcc lattice emits the most particles in the direction of the nearest neighbor packing [110], and very little in the [100] direction; for bcc lattices the direction is [111] and [100]; for diamond lattices, [110] and [100]. A number of the results obtained can be explained by means of the focusing effect of Silsbee-Vineyard. (auth)

**28125** STUDY OF PARAMETERS OF IONIC BOMBARDMENT OF FERRITES. APPLICATION TO THINNING DOWN UNDER SLANTING INCIDENCE ON POROUS MATERIALS. Max Paulus and Francois Reverchon (CNRS, Bellevue, France). Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 223-32(1962). (In French)

The pulverization yield and the surface state of ferrites under bombardment of oxygen ions were studied as a function of the acceleration voltage of the ions, the angle of incidence, and the crystalline orientation. The results obtained were used to choose the experimental conditions for thinning down porous materials under slanting incidence. (J.S.R.)

**28126** STUDY BY ELECTRON MICROSCOPY OF THE EFFECTS OF IONIC BOMBARDMENT ON GLASS. M. Navez, Cl. Sella, and D. Chaperot (CNRS, Bellevue, France) Colloq. Intern. Centre Natl. Rech. Sci. (Paris), No. 113, 233-40(1962). (In French)

The evolution of the morphology of various surfaces of glass exposed to ionic attack under varied incidences and conditions was studied by electron microscopy. The aspect of the attack figures (striae, systems of periodic ridges, cellular structure, etc.) depends essentially on the geometric conditions of the bombardment (angle of incidence of the ionic beam, rotation of the sample, etc.). (tr-auth)

**28127** MECHANISM OF HIGH-POWER-DENSITY ELECTRON BEAM PENETRATION IN METAL. Helmut Schwarz (Rensselaer Polytechnic Inst. of Connecticut, East Windsor Hill). J. Appl. Phys., 35: 2020-9(July 1964).

Electron beams of approximately 2-kw power and acceleration voltages in the range about 100 kv are focused on metal surfaces in spots of 15 to 250 $\mu$ so that maximum power densities of more than $10^{13}$ w/m$^2$ can be achieved. Such electrons penetrate several orders of magnitude deeper into the solid or liquid materials than the classical penetration depth of 100-kev electrons would allow for. A high-speed movie (2500 frames per second) of the process shows that the surface is closed by a liquid film most of the time and that it only ruptures during very short intervals. The temperatures at the surface and in the interior of the welds were determined during the process, experimentally and theoretically, respectively. Also, the dislocation of the metal within the weld was studied with an electron-probe x-ray microanalyzer and with radioactive tracing. Measurements of mass density show that it decreases after the material was affected by the electron beam. A tentative explanation of the effect is offered. (auth)

**28128** STOPPING BY ELASTIC COLLISIONS OF PARTICLES FROM A UNIDIRECTIONAL PLANE SOURCE. E. M. Baroody (Battelle Memorial Inst., Columbus, Ohio). J. Appl. Phys., 35: 2074-85(July 1964).

Calculations are made of certain averages for particles from a plane, unidirectional source being slowed down by elastic collisions in an infinite medium of randomly located target atoms. Calculations are based on the moments form of the Boltzmann transport equation and follow procedures frequently used in the theory of neutron moderation. Assuming isotropic scattering in center-of-mass coordinates, averages are determined for powers of the distance from the source and for Legendre polynomials, which give information on the direction of motion. When the mean free path varies as a power of the energy a number of averages are determined at all energies for equal masses of fast particles and target atoms, and for the first collision interval for unequal masses. Expressions for spatial averages at zero energy are obtained by taking the Laplace transform of the moments equation. For equal masses and $\lambda$ proportional to $E^k$, it is verified that the distribution of stopped particles at moderately deep penetrations is of the form $z^p \exp[-z/\lambda(E_0)]$. For $k > 1$, p is approximately $2/(2k + 1)$. A few comparisons are made with moments calculated by other methods and comments are included on the place of such calculations in the theory of the stopping of kilovolt ions. An appendix reports some preliminary results for anisotropic scattering. (auth)

**28129** PIEZOELECTRIC SENSITIVITY AND REPRODUCIBILITY OF Z-CUT TOURMALINE TO 7 KBAR. J. R. Hearst, L. B. Geesaman, and D. V. Power (Univ. of California, Livermore). J. Appl. Phys., 35: 2145-50(July 1964). (UCRL-7600)

The piezoelectric sensitivities of 20 z-cut tourmaline crystals were compared up to 7 kbar. Deviations from a mean of up to 15% were found. The mean was $1.69 \times 10^{-8}$ C/cm$^2$ · kbar for uniaxial and $2.39 \times 10^{-8}$ C/cm$^2$ · kbar for triaxial tests to 3.5 kbar. A quadratic was fitted to sensitivities obtained from shocking the crystals to 7 kbar. Another set of crystals of different size was compared to the first. Fair agreement was found at high pressures, poor agreement at low. Hysteresis was not observed, nor was directional dependence. (auth)

**28130** ORIENTATION DETERMINATIONS OF CRYSTALS USING EJECTION PATTERNS RESULTING FROM ION BOMBARDMENT. R. L. Cunningham and Joyce Ng-Yelim (Dept. of Mines and Technical Surveys, Ottawa). J. Appl. Phys., 35: 2185-8(July 1964).

Data on six common metals are presented to indicate the general usefulness of ion bombardment for orientation determinations of fcc and bcc crystals. The accuracy is 3° or better and is attained by the use of hemispherical collectors and a simple optical projection device. No film processing is involved and a complete determination, including all operations, usually takes less than 20 min. Patterns for silver, copper, aluminum, tungsten, iron, and beta-brass were obtained using 8-kev argon ions. (auth)

**28131** OCCURRENCE OF NEW COLOR CENTER ABSORPTIONS IN KCl. James G. Ring and L. I. Grossweiner (Illinois Inst. of Tech., Chicago). J. Appl. Phys., 35: 2257-8(July 1964).

An absorption spectrum of additively colored KCl was found, after optical bleaching at 100°C, that shows a band lying between the M and $N_1$ bands. Equivalent results were found with gamma-irradiated ($^{60}$Co) KCl ($2.0 \times 10^{17}$ F centers/cm$^2$). (R.E.U.)

**28132** FIELD EMISSION FROM VACUUM-DEPOSITED METALLIC FILM AND ITS ROLE IN ELECTRIC BREAKDOWN IN VACUUM. R. N. Sudan and F. Gonzalez-Perez (Cornell Univ., Ithaca, N. Y.). J. Appl. Phys., 35: 2269-70(July 1964).

Electric breakdown in a vacuum was investigated by allowing copper vapor from arcing electrodes to be deposited on a tungsten filament, which was kept at a high potential with respect to a collector with a phosphor coating. Fluorescent spots were observed on the screen at 20 kv. (R.E.U.)

**28133** MOLECULAR THEORY OF DISSIPATIVE PROCESSES IN GASES. I. L. McLaughlin (Univ. of Adelaide). J. Chem. Phys., 40: 3166-75(June 1, 1964).

The velocity distribution function associated with a molecule entering a dilute gas, either in equilibrium or with a temperature gradient, is evaluated by solving a forward Boltzmann equation. In the equilibrium case, the velocity distribution function associated with molecules other than the incoming molecule is also evaluated; and the contributions to the Kubo-type coefficient of thermal conduction from both distribution functions are evaluated for Maxwellian molecules. These contributions give the coefficient of thermal conduction obtained by the Chapman-Enskog method. The various mean accelerations experienced by a molecule moving in a gas are calculated using the above solutions of the forward equation and also the solutions of a backward Boltzmann equation. These expressions are then used to evaluate the friction coefficients, first introduced by Kirkwood, for both equilibrium and non-equilibrium gases. An experimental procedure using radioactive particles injected into a gas is also suggested as a method of confirming the results obtained. (auth)

**28134** APPEARANCE POTENTIALS OF POSITIVE AND NEGATIVE IONS BY MASS SPECTROMETRY. Charles E. Melton and William H. Hamill (Univ. of Notre Dame, Ind.). J. Chem. Phys., 41: 546-53(July 15, 1964).

Appearance potentials (AP) of ions were obtained by the retarding potential difference (RPD) technique using a time-of-flight mass spectrometer. Confirmatory measurements were made using a 180° magnetic instrument. Information about processes such as ion-pair formation, electronic excitation of ions, rearrangement of ions, autoionization and metastable transitions is inferred from the structure of the ionization efficiency (IE) curves of Xe, $H_2$, $CH_4$, $CD_4$, $C_2H_4$, $C_3H_6$, $C_3H_8$, and $C_4H_{10}$ over about a 4 ev range. The AP's in Xe at 12.02, 12.35, 12.75, and 14.0 correspond in a qualitative way to autoionization levels. The structure observed in parent and fragment IE curves for hydrocarbons can, in some systems, be correlated with known processes. Structure due to vibrational excitation of ions was not resolved. The IE curves for polyatomic ions indicate that many ions formed by electron impact are formed in electronically excited states, and that appearance potentials of fragment ions often correlate with upward breaks in the parent IE curves. Parent ion intensities did not decrease with increasing electron energy even at large degradation ion intensities. An AP at about 0.7 ev above onset was observed in all the IE curves of $R^+$ from RH and shown to arise from $R^+ + H^-$ formation. The ion-pair process is as probable as the ground-state ion–neutral reaction in the systems investigated. The structure in the fragment IE curves can explain some of the difficulties encountered in measuring appearance potentials. An example of interference by ion–molecule reactions is also reported. Appearance potential data obtained by RPD and by conventional techniques are compared. (auth)

**28135** DIRECT CORRELATION FUNCTIONS AND THEIR DERIVATIVES WITH RESPECT TO PARTICLE DENSITY. R. J. Baxter (Australian National Univ., Canberra). J. Chem. Phys., 41: 553-8(July 15, 1964).

An equation relating the many-body distribution functions of a classical statistical mechanical system and their derivatives with respect to the particle density is stated and proved. It is found possible to define a hierarchy of symmetric functions of 2,3,4, etc. variables, of which the two-variable function is the Ornstein-Zernike correlation function. These functions, termed the direct correlation functions, and their derivatives with respect to density satisfy a strikingly simple relation. The possibility of a closure of the equations is discussed and a superposition approximation suggested. The resulting equation for the two-particle direct correlation function has the advantage that a knowledge of the function at one density predicts its values at another, thereby differing from most approximations, which require the solution of an integral equation in each case. (auth)

**28136** CONFIGURATION INTERACTION IN CRYSTAL FIELD THEORY. K. Rajnak (Univ. of California, Berkeley) and B. G. Wybourne. J. Chem. Phys., 41: 565-9 (July 15, 1964)

The effect of configuration interaction on the validity of the usual method of expanding the crystal field potential in terms of spherical harmonics is examined using second-order perturbation theory. It is found that for a configuration of equivalent electrons $l^N$ most mechanisms of configuration interaction lead to a simple scaling of the crystal field parameters $B^k_q$. However, one-electron excitations, either from the $l^N$ shell to unfilled orbitals or from closed shells into the $l^N$ shell, result in a scaling of the Slater integrals $F^k$ and in overt effects that cannot be accommodated by the $B^k_q$ parameters alone. As a result, the crystal field parameters can be expected to vary from one multiplet to another, even in the limit of Russell-Saunders coupling. The consequences of these overt configuration-interaction effects are discussed. (auth)

**28137** SURFACE POTENTIALS OF NITROGEN ON INDIVIDUAL CRYSTAL FACES OF TUNGSTEN. A. A. Holscher (Koninklijke/Shell-Laboratorium, Amsterdam). J. Chem. Phys., 41: 579-80(July 15, 1964).

A field-emission microscope was used to detect the electrons emitted from nitrogen adsorbed on tungsten. The tungsten was rotated so that individual crystal faces could be investigated. The surface potentials of the individual crystal faces were found to differ in size and magnitude. (C.E.S.)

**28138** BALL LIGHTNING. C. E. R. Bruce (Electrical Research Assn., Leatherhead, Eng.). Nature, 202: 996-7 (June 6, 1964).

It is suggested that the lightning channel may, so to speak, spring a leak at a joint, and allow an escape from it of the jet of hot gas that flows along it, because of the decrease in current and current density in the return stroke from ground to cloud. It is theorized that the velocity of the jet at a discharge temperature of about 30000°K will be about $10^6$ cm/sec and the duration of the high-current period can be several msec, so that the amount of gas that could escape through a square centimeter hole would be several liters, that is, of the order required to explain the size of the balls of ball lightning. (P.C.H.)

**28139** CHARGED BOSE GAS. B. W. Ninham (Univ. of New South Wales, Kensington, Australian). Nucl. Phys., 53: 685-92(May 1964).

The ground-state energy and specific heat of a high density charged Bose gas are computed via the method of Montroll and Ward. The result for the energy is in agreement with a calculation of Foldy. (auth)

**28140** THERMAL DIFFUSION AND DIFFUSION IN HYDROGEN–KRYPTON MIXTURES. E. A. Mason, M. Islam, and Stanley Weissman (Univ. of Maryland, College Park). Phys. Fluids, 7: 1011-22(July 1964). (IMP-AEC-29)

Experimental measurements of thermal diffusion and diffusion over a temperature range of about 195 to 580°K are reported for the systems $H_2$–$^{85}Kr$, $D_2$–$^{85}Kr$, and $T_2$–Kr, and are analyzed to obtain information on intermolecular forces. The measurements are discussed from three separate points of view: (1) their internal consistency within the framework of the Chapman-Enskog kinetic theory, without reference to any specific model of intermolecular forces; (2) the applicability of the 12–6 and exp–6 models of the intermolecular potential; (3) the accuracy of various combination rules used to estimate forces between pairs of unlike molecules. The measurements are shown to be theoretically consistent, but an unresolved discrepancy in the thermal diffusion of $H_2$–$^{85}Kr$ between this work and that of Ghozlan prevents any firm conclusion being drawn on (2). The discrepancy is not too large to prevent some conclusions on (3), and it is found that the exp–6 combination rules work somewhat better than the 12–6 rules. (auth)

**28141** OSCILLATING BOUNDARY LAYER IN MAGNETOHYDRODYNAMICS. I. NONCONDUCTING BOUNDARY. Douglas R. Caldwell (Univ. of Chicago). Phys. Fluids, 7: 1062-70(July 1964).

The hydromagnetic motion caused in an infinite fluid by an oscillating nonconducting boundary was studied theoretically. The results were confirmed experimentally by measurements of the damping of a torsional pendulum suspended in mercury in the presence of an axial magnetic field. (auth)

**28142** EXTENSION OF SIMILARITY RULES FOR THE MAGNETOHYDRODYNAMICAL FLOW. Kinzo Hida (Univ. of Cincinnati). Phys. Fluids, 7: 1073-4(July 1964).

It is shown that similarity rules can be obtained for trans-Alfvénic and hypercritical magnetohydrodynamic flow with a weak shock wave. (C.E.S.)

**28143** PRECURSOR ARC IN AN ELECTRIC SHOCK TUBE. J. P. Barach and J. A. Sivinski (Vanderbilt Univ., Nashville). Phys. Fluids, 7: 1075-6(July 1964).

A grounded probe of fine copper wire was inserted downstream in a coaxial electric shock tube. An arc of some hundreds of amps then preceeded the shock front, running from the high-voltage powering electrode to this ground wire. The precursor current and thickness were investigated. The heating produced by the arc preceding the shock front increased the shock velocity by a factor of 1.4, indicating that the gas temperature ahead of the shock was roughly doubled. (C.E.S.)

**28144** ARGON SHOCK THICKNESS. Morton Camac (Avco-Everett Research Lab., Everett, Mass.). Phys. Fluids, 7: 1076-8(July 1964).

An electron beam technique was used to investigate the shock structure in argon. Large angle scattering of the electron beam was measured. Only a portion of the beam path in the shock tube was used, thus eliminating corrections for shock front curvature. (C.E.S.)

**28145** CONTINUUM RADIATION BEHIND A BLAST WAVE. Robert A. Gross (Columbia Univ., New York). Phys. Fluids, 7: 1078-80(July 1964).

An attempt is made to determine the continuum radiation field emanating from the shock heated gas behind a blast wave. The differential equations that described the flow field behind the blast wave as a function of the mass, momentum, and velocity of the electron, ion, and neutral gas particle are investigated. An equation is obtained for the continuum radiation energy density ratio behind the blast wave. (C.E.S.)

**28146** NOTE ON THE ELECTRON LATTICE. F. W. de Wette (Univ. of Illinois, Urbana and Argonne National Lab., Ill.). Phys. Rev., 135: A287-94(July 20, 1964).

The question of the stability of Wigner's electron lattice, which is the ground state of a dilute electron gas, is considered. To determine the density range in which the electron lattice becomes unstable (coming from lower densities) a simple stability criterion is formulated. It is based on the notion that, in order for a solid structure to exist, the single particle potential should exhibit a localized well with at least one bound state. The disappearance of bound states with increasing density, marking the onset of melting in the model, is related to the possibility of defect formation. In this fashion an upper and a lower limit for the melting density can be established, which are found to occur at densities corresponding to $r_s \approx 47$ and $r_s \approx 100$, respectively ($r_s$ is the radius of the sphere in Bohr units). Consequently, melting of the electron lattice is expected to take place at densities much lower than estimated previously. (auth)

**28147** CONDENSATION OF A CLASSICAL GAS WITH LONG-RANGE ATTRACTION. N. G. van Kampen (Rijksuniversiteit, Utrecht). Phys. Rev., 135: A362-9(July 20, 1964).

The statistical mechanics of a classical gas of hard spheres with long-range attractive interaction is developed. It is shown that condensation occurs, and the thermodynamic properties of the system are derived. Density fluctuations are also calculated. (auth)

**28148** SPECTRAL SHAPE AND ATTENUATION LENGTH FOR HOT ELECTRONS IN THE PRESENCE OF FINITE ABSORPTION. G. A. Baraff (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev., 135: A528-42 (July 20, 1964).

The space and energy distribution of electrons released into a field-free semiconductor provides a means of studying the interaction of the electrons with the material, as experiments by Bartelink, Moll, and Meyer showed. In the presence of finite absorption, or large energy losses per collision, the conventional methods of solving the Boltzmann equation governing the distribution function fail to give reliable results. It was found that a considerable amount of information may be obtained from the Boltzmann equation itself without a spherical harmonic expansion by studying its Laplace transform with respect to energy. An analytic expression for the exponential attenuation length is found which reduces to the BMM expression in the limit of small absorption and small energy loss. Expressions are obtained for the average energy loss and average spread of the distribution, both of which increase linearly with distance, and for the total intensity of the distribution, which decreases exponentially with the distance through which the electrons must diffuse. This form of variation is independent of the energy distribution of the source of hot electrons. Therefore, if the energy distribution of electrons is measured at two different distances from the same source, the rate at which the average energy, for example, decreases with distance may be determined. This rate, being independent of the source distribution, is a characteristic of the medium, as is the BMM

attenuation length. These two quantities together provide sufficient information to determine the mean free path for optical phonon emission and the mean free path for impact ionization. Measuring the energy distribution of the electrons in the medium can be done by measuring the distribution of electrons emitted into the vacuum provided that the angular distribution of the particles is known. This angular distribution may be approximated from knowledge of the Laplace transform. The effect of this analysis on the interpretation of the BMM experiments is to suggest that the mean free path for impact ionization in silicon may be closer to 300 Å than to 200 Å. (auth)

**28149** LONG-RANGE POLARIZATION IN HIGH SUSCEPTIBILITY METALS. B. Giovannini (Université, Geneva), M. Peter, and J. R. Schrieffer. Phys. Rev. Letters, 12: 736-8(June 29, 1964).

By connecting the enhancement of the polarization in momentum space with the observed uniform susceptibility of the studied metal, it is found that exchange interactions between valence electrons can bring into agreement, predicted and observed data on spin polarization of metals and alloys of high paramagnetic susceptibility around magnetic impurities. It is seen that valence-electron exchange interactions strongly modify the form of the induced polarization surrounding a localized moment in Pd, increasing the polarization on the sites neighboring the localized moment. (M.J.T.)

**28150** CONDUCTION ELECTRON SPIN TRANSMISSION IN LITHIUM. Richard B. Lewis and Thomas R. Carver (Princeton Univ., N. J.). Phys. Rev. Letters, 12: 693-4 (June 22, 1964).

The observation of selective transparency of lithium films to microwaves at the resonant frequency of the conduction electron spins is reported. It is concluded that the transmitted signals are due to energy transport by a diffusion of processing conduction electrons through the metal, in confirmation of a previous hypothesis. (M.J.T.)

**28151** RESONANT TRANSMISSION OF MICROWAVE POWER THROUGH "THICK" FILMS OF LITHIUM METAL. N. S. VanderVen and R. T. Schumacher (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. Letters, 12: 695-7(June 22, 1964).

Results of measurements confirming previously-found conduction-electron spin resonance transmission through lithium-metal films are reported. It is demonstrated that (1) the observed line shape is in good agreement with results of detailed calculations, (2) the transmitted fields are circularly polarized, and (3) the signal intensity as a function of sample thickness is exponentially attenuated, with the decay constant expected for diffusing free electrons. (M.J.T.)

**28152** SELF-REVERSAL OF RESONANCE LINES AND ENHANCEMENT OF VIBRONICS IN GADOLINIUM IN CRYSTALS. E. Cohen, U. El-Hanany, and S. Yatsiv (Hebrew Univ., Jerusalem). Phys. Rev. Letters, 12: 703-5(June 22, 1964).

The fluorescence of $GdCl_3 \cdot 6H_2O$ was studied in crystals of 2 to 10 mm thickness and at 77 and 20°K. Effects on vibronic-emission intensity due to repeated self-trapping of resonance radiation were observed. Self-trapping of the resonance 3120 Å group was shown by (1) a well-developed self-reversal of the resonance lines in a high-resolution spectrogram, (2) the increase of the relative intensity of vibronic transitions compared with parent resonance transitions with increasing self-trapping, and (3) the lengthening of the apparent decay time of the fluorescence with increasing crystal thickness. (M.J.T.)

**28153** STATISTICAL MECHANICS OF ADIABATIC PROCESSES. R. D. Mountain (Case Inst. of Tech., Cleveland). Physica, 30: 808-17(Apr. 1964).

The thermodynamic equivalence of an Ehrenfest adiabatic process and an isentropic process is investigated by examining the difference between the susceptibilities calculated under isentropic and Ehrenfest adiabatic conditions. It is found that except under quite restrictive conditions this difference does not vanish. However, it is usually too small to be of thermodynamic significance. The necessary conditions that these processes be thermodynamically equivalent are that the system be able to maintain thermal equilibrium during the process and that the fluctuations of the energy in the canonical ensemble be small. (auth)

**28154** ADIABATIC PROCESSES AND THE EQUATION OF STATE. M. J. Klein and R. D. Mountain (Case Inst. of Tech., Cleveland). Physica, 30: 818-24(Apr. 1964).

It is shown that, if a system satisfies the conditions for exact equality of its isolated and isentropic susceptibilities, then the system has an equation of state of the Grüneisen form. The much weaker consequences of the generally valid asymptotic equality of the susceptibilities are also discussed. (auth)

**28155** REMARKS ON THE TRANSPORT PROPERTIES OF GASEOUS ISOBAR MIXTURES. L. Waldmann (Universität Erlangen-Nürnberg, Erlangen, Ger.). Physica, 30: 914-20(Apr. 1964).

For a binary monatomic gas mixture with components of equal molecular mass (isobar mixture), a special mixture ratio is defined by requiring the Maxwell pure gas relation to hold for the ratio of the viscosity and the heat conductivity in the first Chapman-Enskog approximation. Such a mixture may be called a pseudo pure gas. Its viscosity and heat conductivity are given by the pure gas formulas, its thermal diffusion factor vanishes, and viscosity and heat conductivity, plotted against the mole fraction of the mixture, are extreme. However, the pseudo pure gas must not necessarily lie in the physical range. The pseudo pure para-ortho-hydrogen at low temperature should coincide with iso-hydrogen ($^1/_{10}$ para, $^9/_{10}$ ortho) according to the monatomic theory of Cohen e.a. Comparison with the experiment shows the limits of this theory. (auth)

**28156** SPECTRUM OF MAGNETOHYDRODYNAMIC TURBULENT CONVECTION. S. A. Kaplan (Gorkii State Univ., USSR). Soviet Astron. AJ (English Transl.), 7: 801-5(May-June 1964).

A system of spectral equations of magnetohydrodynamic turbulence, which takes into account the suppression of small-scale motions by the large-scale magnetic field, is proposed. Observational data on the magnetohydrodynamic turbulence of the solar photosphere are used in the derivation of the system. In the small-scale region, the spectral functions of the kinetic and magnetic energies are inversely proportional to the square of the wave number. The critical value of the convective superadiabatic gradient (the value at which instability begins) increases proportionally to the first power of the magnetic field. (auth)

**28157** TRANSACTIONS OF THE AMERICAN NUCLEAR SOCIETY 1964 ANNUAL MEETING, PHILADELPHIA, JUNE 14-17, 1964. Malcolm D. Ferrier, ed. Trans. Am. Nucl. Soc., 7: 1-210(June 1964).

Two hundred and thirty-four summaries of papers are included. One of the papers summarized has been previously abstracted in NSA, as abstract number 18: 16397. (T.F.H.)

*For titles of individual papers see: 27262, 27263, 27334, 27335, 27336, 27450, 27451, 27596, 27597, 27629, 27630, 27635, 27646, 27647, 27664, 27665, 27666, 27667, 27668, 27669, 27670, 27671, 27672, 27673, 27674, 27744, 27745, 27775, 27776, 27802, 27803, 27828, 27829, 27830, 27909, 27910, 27911, 28014, 28015, 28016, 28017, 28018, 28019, 28020, 28021, 28022, 28023, 28024, 28025, 28026, 28067, 28068, 28069, 28070, 28071, 28072, 28073, 28074, 28075, 28076, 28158, 28295, 28296, 28302, 28303, 28309, 28310, 28311, 28312, 28401, 28402, 28534, 28535, 28536, 28537, 28538, 28539, 28540, 28541, 28542, 28543, 28544, 28545, 28546, 28547, 28548, 28549, 28550, 28551, 28552, 28553, 28554, 28555, 28556, 28557, 28558, 28559, 28712, 28713, 28714, 28715, 28716, 28717, 28718, 28719, 28720, 28721, 28722, 28723, 28903, 28904, 28905, 28906, 28907, 28908, 28909, 28910, 28911, 28912, 28913, 28914, 28924, 28925, 28926, 28927, 28928, 28929, 28941, 28942, 28943, 28944, 28945, 28946, 28947, 28948, 28949, 28950, 28951, 28962, 28963, 28964, 28965, 28966, 28967, 28968, 28969, 28970, 28971, 28972, 28973, 28974, 28975, 28976, 28977, 28978, 28979, 28980, 28981, 28982, 28983, 28984, 28985, 28986, 28987, 28988, 28989, 28990, 28991, 28992, 28993, 28994, 29010, 29011, 29012, 29013, 29014, 29015, 29016, 29017, 29018, 29019, 29020, 29021, 29022, 29023, 29024, 29065, 29066, 29067, 29068, 29069, 29070, 29071, 29072, 29073, 29074, 29075, 29076, 29077, 29078, 29079, 29080, 29081, 29082, 29083, 29084, 29085, 29086, 29087, 29088, 29089, 29090, 29091, 29092, 29093, 29094, 29095, 29102, 29109, 29110, 29111, 29112, 29113, 29114, 29115, 29116, 29127, 29128, 29129, 29130, 29131, 29132, and 29133.*

**28158** CURRENT RADIATION SOURCE DESIGN. R. A. Ewing, C. W. Townley, and D. N. Sunderman (Battelle Memorial Inst., Columbus, Ohio). Trans. Am. Nucl. Soc., 7: 209-10(June 1964).

**28159** FORMATION OF NEGATIVE ALUMINIUM, GALLIUM, INDIUM AND THALLIUM IONS DUE TO INTERACTION BETWEEN ELECTRONS AND THE HALIDES OF THESE ELEMENTS. V. I. Khvostenko and A. Sh. Sultanov (Inst. of Organic Chemistry, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1605-7 (May 1964). (In Russian)

Negative aluminum, gallium, indium, and thallium ions were observed as a result of interaction of electrons with the halides of these elements. Negative gallium and indium ions were observed. Negative aluminum, indium, and thallium ions due to interaction between electrons and $AlCl_3$, InBr, and thallium halides are produced as a result of resonance capture of the electron by the molecule with subsequent dissociation into a negative ion and neutral halide atoms. (auth)

**28160** QUANTUM THEORY OF THE PROPAGATION OF ELECTROMAGNETIC WAVES IN METALS IN A MAGNETIC FIELD. V. G. Skobov and E. A. Kaner (Ioffe Inst. of Physics and Tech., Leningrad and Inst. of Radiophysics and Electronics, Academy of Sciences, Ukrainian SSR). Zh. Eksperim. i Teor. Fiz., 46: 1809-19(May 1964). (In Russian)

The high frequency conductivity of a metal in a quantized magnetic field is studied theoretically. It is shown that quantization of the electron states results in gigantic quantum oscillations of the dissipative part of the conductivity tensor related to Landau damping. The effect of these oscillations on the spectrum, damping, and polarization of a helical electromagnetic wave in a metal with an arbitrary carrier dispersion law is considered. It is found that on variation of the magnetic field, the damping and polarization of the helical wave undergo strong quantum oscillations. The effect of electron scattering on the amplitude and shape of the oscillations is investigated. (auth)

**28161** PROPAGATION OF MAGNETO-PLASMA WAVES IN A BISMUTH PLATE. L. A. Falkovskii (Inst. of Physics, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1820-2(May 1964). (In Russian)

Propagation of waves in a plate located in a strong magnetic field is considered. Expressions are given for the amplitudes of waves reflected from or traversing the plate. The reflection coefficient at resonance, that is, when standing waves are established in the plate, appreciably differs from unity. (auth)

**28162** THE MAGNETIC FIELD WITHIN A CYLINDER WITH A ROTATING INTERNAL RADIAL FIELD. R. S. Kuznetskii. Zh. Tekhn. Fiz., 34: 809-11(May 1964). (In Russian)

A magnetic field was found inside a nonconducting cylinder, having a rotating magnetic field of a radial direction on its inside surface. (tr-auth)

**28163** IONIZATION RELAXATION BEHIND A SHOCK WAVE FRONT IN ARGON WITH CESIUM IMPURITY. I. T. Yakubov (Moscow Inst. of Power Engineering). Zh. Tekhn. Fiz., 34: 879-82(May 1964). (In Russian)

In cesium ionization kinetics behind a wave front in argon with cesium impurity, besides the usual ionization mechanisms, interactions with part of the argon atoms are important. The experimentally demonstrated regularities of relaxation time behavior were explained assuming reasonable size for the excitation cross sections of a cesium atom in collisions with argon atoms. (tr-auth)

**28164** INFLUENCE OF A CONSTANT MAGNETIC FIELD ON A STATIONARY CORONA DISCHARGE. V. N. Kostin and V. M. Tkachenko (Gorkii State Univ., Khar'kov). Zh. Tekhn. Fiz., 34: 883-7(May 1964). (In Russian)

Experiments were performed, showing that imposition of a magnetic field produces a displacement of volt-ampere and probe characteristics and changes the radiation spectrum and the coronal-field diameter. An oscillographic method was used. Results showed that, at H = 0 with pressure increase from 20 to 60 mm Hg, the positive hydrogen-ion mobility is diminished to one-third its former value. On imposition of a magnetic field of 500 oersteds at 20 mm Hg, the mobility decreases by several percent. Hydrogen does not usually form negative ions, so in the outer region of negative corona there are only free electrons. The electron mobility decreases more than that of positive ions under the magnetic field. (M.J.T.)

**28165** ON THE TURBULENT MAGNETOHYDRODYNAMIC BOUNDARY LAYER. C. H. Kruger and O. K. Sonju (Stanford Univ., Calif.). p.147-59 of "Proceedings of the 1964 Heat Transfer and Fluid Mechanics Institute." Stanford, Calif., Stanford Univ. Press, 1964.

An analysis that may be useful in the estimation of the importance of magnetic effects upon the turbulent boundary layer on a flat plate and in the prediction of boundary layer

growth and wall friction is described. Attention is directed to the turbulent momentum boundary layer in a conducting fluid with a magnetic field normal to the plate. The boundary layer equations are solved numerically using the Karman-Pohlhausen integral method incorporating wall friction data from the fully developed turbulent flow experiments of Hartmann and Lazarus and Murgatroyd and velocity profiles inferred by Harris from these experiments. Both the wall friction data and the velocity profile relations account for the influence of magnetic interaction through the steepening effect of magnetohydrodynamic forces upon the velocity profile and the dampening effect of the magnetic field upon the scale of turbulence. The resulting velocity profile is no longer similar at varying positions along the plate. Calculations of wall friction and boundary layer thickness were performed for several values of the interaction parameter, Hartmann number divided by Reynolds number. The calculated thickness and wall friction can differ significantly from their values in the absence of a magnetic field. The results show that at large distances downstream of the leading edge the boundary layer thickness approaches an asymptotic value, which decreases as the interaction parameter increases. In addition to the constant property calculations, an assessment is made of the importance of conductivity variation within the boundary layer, through the assumption of a seventh power temperature profile. It is found that this effect decreased the boundary layer thickness in the cases considered. (auth)

**28166** A CRITICAL EVALUATION OF METHODS FOR CALCULATING TRANSPORT COEFFICIENTS OF A PARTIALLY IONIZED GAS. Warren F. Ahtye (Ames Research Center, Moffett Field, Calif.). p.211-25 of "Proceedings of the 1964 Heat Transfer and Fluid Mechanics Institute." Stanford, Calif., Stanford Univ. Press, 1964.

Existing calculations of basic transport coefficients for a partially ionized gas used various approximations that are questionable. The degree of accuracy of these approximations is determined. The approach is to calculate the basic transport coefficients by use of the most accurate theory which is presently available—the second-order Chapman-Enskog formulation. Comparisons are then made between these values and the approximate ones. The approximate values for the viscosity agree with those for the second-order expression within a few percent. However, values of the second-order expressions for the translational thermal conductivity and for certain multicomponent diffusion coefficients are larger than the approximate values by 25 to 50 percent at large degrees of ionization. The existing approximations result in a zero value for the thermal diffusion coefficient. The more exact theory predicts appreciable effects of thermal diffusion. In fact, the thermal diffusive component of the thermal conductivity, which is assumed negligible, can be appreciable even for small values of the concentration gradients. It can be shown that these effects can be attributed almost entirely to the thermal diffusion of electrons. Comparisons of the multicomponent and thermal diffusion coefficients for the various species indicate that the diffusive motions of the ion and atom are independent of the diffusive motion of the electron up to high degrees of ionization. The approximate method for predicting the reactive component of the thermal conductivity is inexact in many areas, the main defect being the neglect of charge separation effects. (auth)

**28167** SECONDARY ELECTRON EMISSION FROM SINGLE CRYSTALS OF TITANIUM, GERMANIUM, TUNGSTEN, AND BERYLLIUM. George Gabriel Goetz. Thesis, Minneapolis, Univ. of Minnesota, 1963. 121p.

A careful re-examination was made on the secondary emission from single crystals to the angle of incidence of the primary beam, re-examination of the $\delta(\theta)$, characteristics of a material previously investigated, titanium, and an examination of three materials not previously studied, tungsten, germanium, and beryllium. The only theory that has been proposed as an explanation of the structure observed in the $\delta(\theta)$ curves for crystals was quantitatively tested and found to yield peaks much smaller than those experimentally observed. A new model is proposed that appears capable of qualitatively accounting for nearly all of the properties of the $\delta(\theta)$ structure that were observed with the materials studied. The model involves the dependence of the rate of energy dissipation of the primaries upon their initial direction when entering the crystal. The crystal geometry determines the directions of relatively high rates of energy loss by means of interactions with the crystal electrons. (Dissertation Abstr., 24: No. 11, 1964)

**28168** COMPTES RENDUS DE LA VI$^{e}$ CONFÉRENCE INTERNATIONALE SUR LES PHÉNOMÈNES D'IONISATION DANS LES GAZ, PARIS, 8-13 JUILLET 1963. VOLUME III. (Proceedings of the VIth International Conference on Ionization Phenomenon in Gas, Paris, July 8-13, 1963. Volume III). P. Hubert and E. Crémieu-Alcan, eds. Paris, SERMA, 1963. 443p. (CONF-75)

Eighty-one papers and 3 abstracts of papers are included. Separate abstracts were prepared for 68 papers. Nine papers were previously abstracted for NSA; see abstracts 17: 33215, 35022, 36386, 36749, 42046; 18: 1141, 14754, 21375, 22931. The 4 papers not abstracted consider $N_2^+$ oscillator strength, radiation from nitrogen and air shocks, neon transition probabilities, and shock tube spectroscopy. (M.J.T.)

*For abstracts of individual papers see: 28169, 28170, 28171, 28172, 28173, 28174, 28175, 28176, 28414, 28828, 28829, 28830, 28831, 28832, 28833, 28834, 28835, 28836, 28837, 28838, 28839, 28840, 28841, 28842, 28843, 28844, 28845, 28846, 28847, 28848, 28849, 28850, 28851, 28852, 28853, 28854, 28855, 28856, 28857, 28858, 28859, 28860, 28861, 28862, 28863, 28864, 28865, 28866, 28867, 28868, 28869, 28870, 28871, 28872, 28873, 28874, 28875, 28876, 28877, 28878, 28879, 28880, 28881, 28882, 28883, 28884, 28885, and 28886.*

**28169** INSTABILITY OF THE TWO BEAM TYPE IN A COLD-CATHODE PIG DISCHARGE. Samuel Bliman (Institut d'Electronique, Orsay, France). p.233-6 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

In a cold-cathode PIG discharge, a working domain was found, where the discharge behaves like a system of two electron beams of the same velocity circulating in opposite directions. Under certain potential and magnetic-field conditions, h-f emissions related to previous predictions are observed. (auth)

**28170** INFLUENCE OF ELECTROMAGNETIC FIELD ON THE DIPOLE MOMENTS AND ON THE FREQUENCY OF LINES OF ATOMIC HYDROGEN. Nguyen-Hoe, E. Banerjea, H.-W. Drawin, and L. Herman (EURATOM-CEA, Fontenay-aux-Roses, France and Laboratoire des Recherches Physiques de la Sorbonne, Paris). p.299-306 of "VI$^{e}$ Confér-

ence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

Atomic-level displacements and electric-dipole matrix elements of atomic hydrogen in a uniform electric field were determined as precisely as possible. The potential from which this field is derived is considered as a disturbing element of the radiating atom. A perturbation method was chosen in such a way as to facilitate the automatic calculation by computers. Results are given only for atomic levels (line frequencies) expressed in series form entirely as a function of the exterior field. (tr-auth)

**28171** STUDY OF EMISSION OF AN ARC IN THE VISIBLE AND FAR INFRARED REGIONS. R. Cano, M. Capet, I. Fidone, M. Mattioli, and R. Papoular (EURATOM-CEA, Fontenay-aux-Roses, France). p.315-22 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

A highly ionized hollow cathode and anode discharge was produced in a container of stainless steel. The arc configuration determined by the guiding magnetic field allows axial observation for a length of about two meters. The arc runs from the inside of a tantalum cathode to a copper anode. The gas (Ar, $D_2$, $H_2$, He) can be introduced either at the cathode or at the anode. Microwave and electrostatic probe measurements indicated a density higher than $10^{14}$ $cm^{-3}$. Spectroscopic observations in the range between 2000 and 7000 Å showed lines of doubly ionized argon. The far infrared emission (0.1 to 10 mm) was analyzed with an interference spectrometer and detected with a Golay cell. The spectrum is compared with the theory. (auth)

**28172** RADIATION CHARACTERISTICS OF "HIGH PRESSURE" ALKALI METAL DISCHARGES. Kurt Schmidt (General Electric Co., Cleveland). p.323-30 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Alkali metal vapor discharges were operated wall stabilized at power densities up to 350 $w/cm^3$ to obtain the spectral distributions of sodium, potassium, rubidium, and cesium, each at vapor pressures of 30, 240, 540, and 1000 torr. Similarities of band emission among all four elements are discussed. Maximum luminous efficiencies were measured as follows: sodium, 145 LPW; potassium, 10 LPW; rubidium, 21 LPW; and cesium, 35 LPW. (auth)

**28173** A VACUUM SLIDING SPARK FOR THE EXCITATION OF AN INTENSE Li III SPECTRUM. P. Bogen and H. Conrads (Institut fur Plasmaphysik der Kernforschungsanlage, Julich, Ger.). p.337-40 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

A sliding spark with a total inductance of 20 nh was developed. The Li electrodes were separated by a polyethene insulator containing a Li disk. At 10 kv the Lyman lines and continuum of Li III were produced. Also the most intensive spectral line of the Paschen series was observed. The electron density was determined by the formula of Inglis and Teller to be $10^{18}$ $cm^{-3}$, and the electron temperature from the decrease of the Lyman continuum of Li III, to be 20 ev. It seems possible to make relative and absolute intensity measurements in the short wavelength uv (100Å) by comparing spectral lines from Lyman and Paschen series coming from transitions with the same upper level. (auth)

**28174** FORBIDDEN AURORAL RADIATION FROM GAS MIXTURES. J. W. McConkey, D. J. Burns, and K. G. Emeleus (Queen's Univ., Belfast). p.363-8 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

An investigation is described of the forbidden radiation from high pressure Tesla-type discharges in oxygen-nitrogen-argon gas mixtures. Studies of the radiation from the direct discharge and its afterglow were made. The afterglow proved to be a good source of forbidden atomic lines of oxygen and nitrogen and of the Vegard-Kaplan bands of molecular nitrogen. A study was made of the variation of forbidden spectra intensity with plasma parameters. (auth)

**28175** SOME GAS DISCHARGE ASPECTS OF THE HELIUM–NEON LASER. J. Haisma and G. Ahsmann (N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands). p.369-71 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

A small, stable construction of a gas laser with flat mirrors and dc excitation is described. The laser output of the 1.1530 micron neon line ($2s_2 - 2p_4$ transition) versus the dc input power of the gas discharge is considered in terms of the discharge mechanism. (auth)

**28176** WAVELENGTH ANALYSIS OF FLUORESCENCE FROM GASES EXCITED BY VACUUM ULTRAVIOLET RADIATION. D. L. Judge, A. L. Morse, and G. L. Weissler (Univ. of Southern California, Los Angeles). p.373-9 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

A wavelength analysis of the pressure dependence of visible fluorescence of several gases is presented. The excitation energy required to obtain fluorescence is discussed, and the fluorescence efficiency is estimated. The source radiation consisted of a line spectrum from which photo-energies between 12 and 24 ev were selected. The wavelength analysis of the fluorescent radiation was obtained using a monochromator having a bandwidth of 100 Å. The low resolution was required in order to pass a detectable light flux through the instrument. The present results represent an extension of those reported earlier regarding the observed undispersed fluorescent radiation of the atmospheric gases. (auth)

**28177** INVESTIGATION OF MULTIPLE CHARGE TRANSFER FOR THE PRODUCTION OF COLLIMATED DENSE, FAST ATOM BEAMS. G. J. Brucker and B. B. Aubrey. 9p. (CONF-471-3)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

Evidence that the cross section for scattering of fast atoms by slow atoms is smaller than the ion-atom charge transfer cross section in noble gases and Cs indicated the possibility of producing fast atom beams by use of a lower-density atom beam in which a slow ion is reaccelerated after each charge transfer to produce numerous fast-atom offspring. An experiment was performed demonstrating multiple charge transfer with gain. Preliminary measurements of the charge transfer and scattering cross section for 500-v Ar ion and atoms indicated values of $3.4 \times 10^{-15}$ and $5.2 \times 10^{-16}$ $cm^2$, respectively. The fast-slow neutral scattering cross section was measured for scattering outside of a solid angle of $3 \times 10^{-3}$ steradians. The ratio of charge exchange to scattering cross section sets an upper limit of ~6 mean free paths to the length of the charge exchange chambers and of 6 for the possible gain. (auth)

**28178** FREQUENCY-DEPENDENT RELAXATION TIME OF ELECTRON-PHONON SYSTEMS IN A HOMOGENEOUS MAGNETIC FIELD. Y. C. Lee and N. Tzoar (Bell Telephone Labs., Inc., Whippany, N. J.). 20p. (CONF-471-11)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

The problem of electromagnetic wave absorption in a simple model of metal, consisting of electrons and phonons in the presence of a uniform static magnetic field, is investigated by a quantum-kinetic description. The treatment, which stems from a proper time-dependent transport equation, does not have the time scale restriction of the usual transition probability approach and does give a proper description of the time-dependent collective effects in a self-consistent way. (auth)

**28179** DUOPLASMATRON-TYPE ION SOURCE INCLUDING A NON-MAGNETIC ANODE AND MAGNETIC EXTRACTOR ELECTRODE. Norman B. Brooks and Bertram S. Quintal (to High Voltage Engineering Corp.). U. S. Patent 3,137,801. June 16, 1964. Filed Sept. 22, 1960.

A duoplasmatron ion source is designed with a novel magnetic circuit. In this magnetic circuit, the grounded anode is made of Al or other nonmagnetic material, while the extractor electrode is made of magnetic material such as Fe. Thus, the magnetic circuit runs across the anode and through the electrode, and the ion beam is prevented from burning up the electrode. (D.L.C.)

## Accelerators

*Refer also to abstracts 27793, 27840, and 28254.*

**28180** (NP-13999) ENTWICKLUNG EINES 100-Mev FFAG-ELEKTRONEN-SYNCHROTRONS. Bericht Nr. 15. (Development of a 100-Mev FFAG Electron Synchrotron. Report No. 15). W. Heinz (Berlin. Freie Universität. I. Physikalisches Institut). [Jan. 1964]. 20p.

Development of a 100-Mev FFAG electron synchrotron is described under 4 topics. Separate abstracts were prepared for each. (M.C.G.)

*For abstracts of individual papers see: 28181, 28182, 28183, and 28184.*

**28181** (NP-13999(p.1-3)) ZUR FESTLEGUNG DER GERÄTEPARAMETER FÜR DAS 100-Mev FFAG-ELEKTRONENSYNCHROTRON. (On the Fixation of Instrument Parameters for the 100-Mev FFAG Electron Synchrotron). W. Heinz (Berlin. Freie Universität. I. Physikalisches Institut).

Calculations for conclusive determination of instrument parameters and work points are in progress. The maximum permissible deviations of the radial and vertical betatron oscillation frequency during an acceleration cycle was determined from resonance diagrams and from those an upper limit for permissible changes in the average field index and the angular distribution were ascertained. It is shown that changes in the ratios of Fourier coefficients of the first degree of development for constant rank had differing influences on the size of the betatron oscillation frequency, while an additional harmonic vibration content had only a slight frequency shift as a result. (tr-auth)

**28182** (NP-13999(p.4-7)) IMPULSGENERATOR UND IMPULSTRANSFORMATOR FÜR DEN INJEKTOR ZUM 100-Mev FFAG-ELEKTRONENSYNCHROTRON. (Impulse Generator and Impulse Transformer for the Injector of the 100-Mev Electron Synchrotron). J. Fronia and W. Heinz (Berlin. Freie Universität. I. Physikalisches Institut).

Investigations were undertaken for the transformation of injection pulses. Suitable impulse transformers were calculated and wound. The influence of a scattering capacity and scattering inductivity on the transformation characteristics was investigated. It was found that the time constants for the scattering capacity of the secondary winding and the secondary cutoff resistance and the adjustment of scattering capacity and scattering inductivity of the secondary side of the transformer to the wave resistance influenced the track time series of the transmission characteristics. The first measurements on the electron source gave a pulse of 80 kv, 0.8 μsec duration, and an energy distribution of $\Delta E = \pm 2\%$ over a region of 200 nsec or $\Delta E = \pm 2\%$ over a region of 20 nsec. (tr-auth)

**28183** (NP-13999(p.8-10)) ARBEITEN FÜR DIE ELEKTRONENQUELLE DES 100-Mev FFAG-ELEKTRONENSYNCHROTRONS. (Report on the Electron Source of the 100-Mev FFAG Electron Synchrotron). W. Heinz (Berlin. Freie Universität. I. Physikalisches Institut).

The electron source was completed. It is being mounted and mechanically adjusted. The supply units for heating voltage and grid potential were built and their influence on the pulse form investigated. (tr-auth)

**28184** (NP-13999(p.11-15)) UNTERSUCHUNGEN AN EINEM STRAHLERZEUGUNGSSYSTEM NACH PIERCE FÜR HOHE SPANNUNGEN UND HOHE STROMSTÄRKEN. (Study on the Beam Production System After Pierce for High Voltage and High Current Intensity). G. Hoffmann (Berlin. Freie Universität. I. Physikalisches Institut).

Further measurements with the chosen electrode form were carried out. The voltage of the focussing electrode and the position of the cathode were varied and by determination of the electron path, qualitative statements on the behavior of the electron beam could be made. Dimensional control for the Pierce electron gun was improved and the electrode form in an electrolytic tank was determined. (M.C.G.)

**28185** (NP-14015) ARBEITEN FÜR DEN BAU DES 100-Mev FFAG-ELEKTRONENBESCHLEUNIGERS. Bericht Nr. 2/1962. (Report on the Structure of the 100-Mev FFAG-Electron Accelerator. Report No. 2/1962). G. Wohlfeil (Berlin. Freie Universitat. I. Physikalisches Institut). Nov. 12, 1962. 12p.

Work on the 100-Mev FFAG accelerator is described. Formulization and programming for numerical integration of differential equations for equilibrium orbits with radial and vertical betatron frequencies, were concluded and tested. The results yielded large variations from the previously used approximation calculation. The results led to a sector number N = 12 and a field gradient K = 8 as work points. The model magnet was modified for simultaneous changes in vertical aperture and the field-generating winding changed. The long-time constant of the magnetic current was improved to about $5 \times 10^{-4}$. (tr-auth)

**28186** (PAN-294) PIECIOLECIE PRACY CYKLOTRONU KRAKOWSKIEGO. (Five Years of Operation of Krakov Cyclotron). (Polish Academy of Sciences. Inst. of Nuclear Physics, Krakow). 1963. 24p.

**28187** (ORNL-3578(p.122-6)) SUPPORT FOR THE HIGH-VOLTAGE ACCELERATOR PROGRAM. (Oak Ridge National Lab., Tenn.).

By superimposing a 31.25-kc signal on a deflector system with a countdown frequency of 125 kc, a 32-μsec

repetition rate may be obtained from the 3-Mv ORNL Van de Graaff. This gives a choice of 1 Mc basic rate to 500, 125, or 31.25 kc for the pulse repetition rate. A klystron buncher capable of delivering high voltage to the buncher electrode has replaced the previous 3-Mv ORNL Van de Graaff buncher. Measurements of buncher effect on pulse duration at beam energies up to 2.1 Mv and on beam energy spread at 1.747 Mv have been made. A new inclined-field accelerator tube, two product-90 analyzing magnets, and an improved tank gas mixture have improved operations on the Tandem machine by reducing terminal radiation levels, extending the useful energy range of analyzed beams, and increasing the allowable terminal voltage. Two methods of producing a negative hydrogen-ion beam were investigated: charge exchange of a positive ion beam in a gas target; and direct extraction from the plasma in a duoplasmatron ion source. The best results were obtained with direct extraction. A negative-ion beam of 30 μa and of good ion optical quality was extracted through a source aperture of 0.0085 in. A hot-wire thermal leak valve, based on a Harwell design, was developed for accelerator ion-source gas feed. By using the same heater as is used for the ORNL palladium leak valve, the control system does not have to be changed when the thermal valve is used in place of a palladium leak valve for feeding gases other than hydrogen (that is, helium, oxygen, bromine, and iodine). (auth)

**28188** (ORNL-3630(p.38-62)) OAK RIDGE ISOCHRONOUS CYCLOTRON. R. J. Jones, R. S. Livingston, E. D. Hudson, et al. (Oak Ridge National Lab., Tenn.).

Beam extraction, external beam optics system, r-f system improvements, and magnet power supplies and modifications are discussed. Stable operation of ORIC is reported. (R.E.U.)

**28189** (ORNL-3630(p.63-112)) HIGH-ENERGY ACCELERATOR DEVELOPMENT. J. A. Martin, R. S. Livingston, J. B. Ball, et al. (Oak Ridge National Lab., Tenn.).

Development studies for the $Mc^2$ Cyclotron are discussed. The Separated-Orbit Cyclotron was analyzed for possible advantages over older accelerator types. Superconducting magnet development is discussed. (R.E.U.)

**28190** (TID-20660) MULTIPLE-HARMONIC BUNCHER FOR A LINEAR ACCELERATOR. Rolland Perry (Argonne National Lab., Ill.). Feb. 22, 1963. Contract W-31-109-eng-38. 26p.

It is known that the capture efficiency of a standing-wave linac can be increased by two or more by velocity modulation of the d-c beam in an r-f cavity to which a sinusoidal voltage is applied at linac frequency, and then permitting the ions to drift a distance before entering the linac, thus phase bunching them somewhat. It is shown that a further increase in capture efficiency can be achieved using additional buncher cavities driven at harmonics of the linac frequency. Capture efficiency of 80 to 90% seems possible using two to four harmonics. (R.E.U.)

**28191** (UCRL-10870) EFFECT OF GRADIENT ERRORS IN THE PRESENCE OF SPACE CHARGE FORCES. Lloyd Smith (California. Univ., Berkeley. Lawrence Radiation Lab.). July 11, 1963. Contract W-7405-eng-48. 11p. (CONF-114-26)

From the International Conference on High Energy Accelerators, Dubna, U.S.S.R., Aug. 1963.

The space-charge limit of an alternating gradient synchrotron is usually estimated by computing the change in betatron frequency of individual particles within the beam due to the space-charge force and then imposing the condition that the working point should stay within the original integer–half-integer diamond. A quantitative estimate of instabilities with respect to gradient errors is presented. (R.E.U.)

**28192** ADONE; 1.5-Bev ELECTRON AND POSITRON STORAGE RING. F. Amman, R. Andreani, M. Bassetti, et al. (Laboratori Nazionali, Frascati, Italy). Comit. Nazl. Energia Nucl., Notiziario, 10: No. 3, 16-31(Mar. 1964). (In Italian)

Adone, the 1.5-Bev electron and storage ring under construction at the Frascati National Laboratories, is described in some detail. The principal characteristics of the storage ring are tabulated. Experiments with crossed beams of electrons and positrons possible with the Adone are summarized. The general design considerations in the Adone are given. (J.S.R.)

**29193** RUSSIA'S NEW PROTON SYNCHROTRON. Indian Eastern Engineer, 106: 43-5(Jan. 1964).

The construction of the world's biggest particle accelerator, being built in the Soviet Union, is described. The new accelerator will produce protons with an energy of 70 Bev and will be the first machine to have an energy greater than the hypothetical accelerator based on the terrestrial magnetic field. Some problems to be studied with the new accelerator are discussed and the operating principles of the new accelerator are described. It is based on the principle of strong focusing. Though the particles are accelerated to higher energies, neither the chamber retaining the beam nor the magnets are any bigger. Therefore, although the new accelerator will be about a half km in dia, the magnets will total about 20,000 tons in wt—a moderate figure for such a machine. The accelerator is 480 m in dia, and the orbit to be covered by particles will be 1480 m. The vacuum chamber measures 120 by 200 mm in cross-section. Arranged lengthwise inside it are 120 magnets, each divided into five segments. Each magnet is 10 m long. The adjacent magnets must be aligned accurately to within 0.2 mm. The foundation of the accelerator has been laid on medium-density limestone deposits. The magnets are set on bridges 10.5 m long, which are mounted on suitable adjusting devices, which are in turn carried by concrete supports. The concrete race will have a powerful air-conditioning system. Near the circular race at one side is a long building for housing the injector, which is a linear accelerator imparting to protons an energy of 100 Mev before they are injected into the proton synchrotron proper. Protons will be injected at the rate of six times per min, and in a few seconds they will be covering a distance greater than that from the Earth to the Moon. (BBB)

**28194** INVESTIGATION OF THE ENERGY SPECTRUM OF THE ELECTRON BEAM OF THE 7.5-Mev BETATRON. B. A. Kononov, V. M. Antonov, and V. V. Evstigneev (Tomsk Polytechnic Inst., USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 400-3(Feb. 1964). (In Russian)

The spectrum of the electrons ejected by a 7.5-Mev betatron was examined by means of a magnetic $\beta$ spectrometer. The dimensions of the device are much larger than is usual for its energy level and thus it was possible to place instruments and irradiation samples at points where the electron beam had its highest intensity. The betatron, which operates at a current of $10^{-6}$ amp, was placed on a movable support and could be rotated around its vertical axis. The electron beam was extracted from the betatron by an electrostatic method. The spectrometer used was calibrated by the photoelectrons generated by the

γ quanta of $^{60}Co$; it was designed to operate with electrons up to 15 Mev. At 6.4 Mev, the half-width of the line was 172 kev, corresponding to 2.7%; this value is mostly attributable to the dimension of the slit, to aberrations of the instrument, and to voltage instability in the magnet. Under other than optimal conditions it was found possible to increase the half-width of the energy distribution of the electrons in the extracted beam to 5%. Although this is of little importance for devices used for medical studies and for radiation chemistry, the betatron must be provided with a stabilizing system if high-precision physical experiments are carried out with it. (TTT)

**28195** REMOTELY OPERATED EQUIPMENT FOR VAN DE GRAAFF ACCELERATORS. Jiří Schaeferling, František Šrepl, and K. Rytina (Inst. for Nuclear Research, Czechoslovak Academy of Sciences, Rez). Jaderna Energie, 10: 57-9(1964). (In Czech.)

The ion or electron sources of Van de Graaff accelerators are usually placed on the high-voltage electrode. The target room and the control room are therefore separated from the source by a potential difference of several megavolts. In order to enable operators to make necessary measurements without exposure to high voltage, a remote device was installed on the electrostatic accelerator. It operates on the principle of light beam impulses, which repeat the scintillation of the instruments placed near the source, with the light intensity proportional to the value to be measured. A precision of 1% was achieved with this system, which operated satisfactorily over a potential difference of 5 Mv. (TTT)

**28196** SPACE-CHARGE EFFECT OF THE BEAM UPON THE PHASE VELOCITY OF AN ACCELERATING WAVE. Vaclav Sochor (Czech Technical Univ., Prague). Jaderna Energie, 10: 111-13(Apr. 1964). (In Czech)

The dependence of phase velocity of an accelerating wave in an h-f electron accelerator on the space charge of the beam was investigated. A continuously injected and velocity-modulated beam was considered. At velocities close to the velocity of light the influence of space charge in a continuously injected beam appeared to be negligible. The modulation of a beam in clusters, even at nonrelativistic velocities caused a substantial decrease of this effect. Calculations were made for a 3-Mev h-f linear accelerator. (auth)

**28197** SECONDARY ELECTRON RESONANCE DISCHARGE. II. STEADY STATE BY RETURN. D. K. Callebaut, J. L. Verhaeghe, and M. J. Bouten (Interuniversitair Instituut voor Kernwetenschappen, Ghent). Physica, 30: 825-47(Apr. 1964).

The Coulomb interaction between the electrons is taken into account, but the return mechanism prevails instead of the debunching. It becomes clear which parts of the multipactordomain belong to the return mechanism and to the debunching respectively. Approximate equations governing the steady state are derived, and the corresponding current is calculated. All equations are put in a general and elegant form by the use of dimensionless quantities. Although the return mechanism is essentially different from debunching, the general conclusions are unaltered. The reduced potentials $u_0$, $\sqrt{2u_k}$ and $u_e$ are comparable in magnitude. The multipactor charge increases with the square of the frequency if the product frequency times electrode separation is kept constant. The limit of the secondary electron resonance discharge domain due to return is shifted toward the lower $u_0$ values as compared to the limit obtained by the elementary theory because the secondary velocity distribution is taken into account by two parameters instead of one. Some other causes influencing the steady state are briefly discussed. The lowering of the h-f power of a linear accelerator is estimated. A comparison is made with the charge determined experimentally by Krebs and Meerbach. (auth)

**28198** THE CERN PROTON SYNCHROTRON, 1954–1962: FORECASTS AND REALITY COMPARED. AN INFORMAL TALK. M. G. N. Hine (CERN, Geneva). p.287-94 of "Selected Topics on Elementary Particle Physics." New York, Academic Press, 1963.

The general design and performance of the CERN proton synchrotron are surveyed. Methods of using the accelerator—targets, beams, layout, and general facilities—are considered. Experimental technique and the type of problems for which the machine is used are discussed. (M.J.T.)

**28199** ON LINE HANDLING SYSTEM FOR THE NBS LINAC. J. Broberg, J. Leiss, R. A. Schrack, and J. M. Wyckoff (National Bureau of Standards, Washington, D. C.). 11p. (CONF-182-17)

From the 9th Scintillation and Semiconductor Counter Symposium, Washington, D. C., Feb. 1964.

A data-handling system using an on-line computer and the building-block concept is being developed for the NBS linear accelerator. The types of experiments for which the system will be used, input-output devices and requirements and the program organization that permits concurrent use of the system by several experimental groups are discussed. System features, general design, and operation are also described. (D.C.W.)

**28200** HIGH-CURRENT PULSED ION SOURCE. George C. McFarland (to High Voltage Engineering Corp.). U. S. Patent 3,137,820. June 16, 1964. Filed May 1, 1958.

An ion source is designed for producing large ion currents of the order of amperes, for use in particle accelerators, etc. A suitable gas to be ionized is passed into a chamber, high-voltage pulses are applied between a grounded flange and an anode, and the positive ions in the periodic discharge are removed by an extractor with a negative voltage. The high-voltage pulses are produced by several condensers controlled by a thyratron and a pulsing mechanism. (D.L.C.)

## Astrophysics and Cosmology

*Refer also to abstracts 28287, 28468, and 28809.*

**28201** (NP-13988) SHOCK WAVES IN INTERPLANETARY PLASMA. Paul J. Kellogg (Minnesota. Univ., Minneapolis. School of Physics). Feb. 1964. 14p. (CR-69)

The structure of the shock wave around the earth (postulated) and the front of an approaching solar plasma cloud were studied to improve the predictions of Parker's shock-wave theory with regard to Forbush decreases. Collisions are considered negligible and two-stream plasma instability is introduced as a dissipation mechanism. (R.E.U.)

**28202** PLASMA AND INTERSTELLAR MAGNETIC FIELD. V. C. A. Ferraro (Univ. of London). Cahiers Phys., 17: 448-54(Oct.-Nov. 1963). (In French)

Evidence in favor of the existence of an interstellar magnetic field is surveyed. Arguments based on the concept of imprisonment of cosmic rays by the galactic magnetic field, polarization of light from stars, low-frequency radiation emitted by the galactic disk and halo, and the equilibrium

and stability of the spiral arms of nebular are considered. It is concluded that the existence of the galactic magnetic field is likely, but not yet proved. (M.J.T.)

**28203** ON THE ORIGIN OF GAS-RICH METEORITES. H. E. Suess (Univ. of California, San Diego, La Jolla), H. Waenke, and F. Wlotzka. Geochim. Cosmochim. Acta, 28: 595-607(May 1964).

Meteorites that contain large amounts of primordial rare gases, i.e., the so-called gas-rich meteorites, always show a light–dark structure. They consist of light parts imbedded in a matrix of much darker material. Only the dark material contains the rare gases. Mineralogical and chemical evidence shows that gas content and light–dark structure of this class of meteorites cannot have originated simultaneously with the formation of sulfides, nor can it have been produced by violent shocks. Although the chemical composition of the minerals in the light and in the dark parts is practically identical, the structure of these meteorites is not that of a pseudobreccia produced in situ, but that of a true polymict breccia formed by agglomeration of various types of fragments. Content and distribution of primordial rare gases and their isotopes in these meteorites can best be explained by assuming incorporation of the gases by particle radiation such as solar wind. A possible relation to comets is mentioned. (auth)

**28204** ON THE ASYMMETRICAL MAGNETIC AND IONOSPHERIC EFFECTS CAUSED BY THE LARGE SUNSPOTS WHICH APPEARED ON THE NORTHERN AND THE SOUTHERN HEMISPHERE OF THE SUN. Yinn-nien Huang (Ministry of Communications, Taiwan, China). J. Atmospheric and Terrest. Phys., 26: 607-13(May 1964).

The superposed-epoch method is used to study the geomagnetic effect caused by the large sunspots with areas greater than 1000 millionths of the sun's disc. The results show that the geomagnetic activity caused by the large sunspots on the northern hemisphere is larger than that caused by those on the southern one. The same method was used to study the ionospheric effect of the large sunspots. The results show that the noon $f_0F2$ corresponding to the sunspots which appeared on the northern hemisphere is smaller than that corresponding to the sunspots which appeared on the southern hemisphere. One of the possible reasons for the smaller value of $f_0F2$ is that the geomagnetic activity caused by the northern sunspots is larger than that caused by the southern ones. (auth)

**28205** POLAR CAP AURORA AND MAGNETIC ACTIVITY. R. A. Hamilton (The Observatory, Lerwick, Shetland, Scotland). J. Atmospheric and Terrest. Phys., 26: 615-18 (May 1964).

Visual auroral observations made near sunspot minima at two stations occupied by the British North Greenland Expedition during the winters of 1952-3 and 1953-4 are examined. Much greater aurora frequency was observed in the morning than in the evening, at the southern station than at the one 359 km north, and during 1952-3 than during 1953-4. Data were examined for correlations of auroral frequency with planetary magnetic activity and sunspot number. (M.J.T.)

**28206** IONOSPHERIC ABSORPTION IN CONJUGATE REGIONS AND POSSIBLE OSCILLATION OF THE EXOSPHERE. H. J. A. Chivers and J. K. Hargreaves (National Bureau of Standards, Boulder, Colo.). Nature, 202: 891-3(May 30, 1964).

Riometer measurements taken at three pairs of magnetically conjugate stations at high latitude are given for 30-Mc cosmic radio noise (Aug. 21, 1963). It is suggested that the fluctuations of conjugate absorption ratio are caused by oscillations of the magnetosphere. (R.E.U.)

**28207** REGULARITIES IN THE OCCURRENCE OF SOLAR FLARES. Irvine Paghis (Defence Research Telecommunications Establishment, Ottawa). Nature, 202: 992-4(June 6, 1964).

Striking regularities in the occurrence of intense solar flares were investigated. Work began with the assumption that regular variations, with periodicities of the order of several days, occur on the sun. It was assumed that one manifestation of their existence is the occurrence of discrete solar disturbances. The general concept was that the probability of occurrence of an event, such as an intense flare, is determined by the phase of the assumed solar periodic variations. Solar data were restricted to the starting times of flares listed by at least one observatory as of importance $\geq 2$. All flares were included, regardless of their location on the solar disk. Results of the analysis are discussed. (P.C.H.)

**28208** ON POSSIBLE EXISTENCE OF NEUTRINO SUPERSTARS. M. A. Markov (Lebedev Inst. of Physics, Moscow). Phys. Letters, 10: 122-3(May 15, 1964).

The parameters of a star consisting of a degenerate ideal neutrino gas are considered, and the possibility of the existence and evolution of neutrino superstars is discussed. (C.E.S.)

**28209** THE INDICES OF SOLAR ACTIVITY. G. Godoli and C. W. Allen (London Univ.). Planetary Space Sci., 12: 349-54(May 1964).

The quantitative expressions used for describing the various characteristics of solar activity are considered. Indices for sunspots, faculas, flares, prominences, filaments, coronal spectra, and radio emission are discussed. Thirty-eight references are cited. (C.E.S.)

**28210** THE SOLAR EXTREME ULTRAVIOLET RADIATION (1-400 Å). John C. Lindsay (Goddard Space Flight Center, Greenbelt, Md.). Planetary Space Sci., 12: 379-91(May 1964).

Principal observations of solar extreme ultraviolet radiation (1–400 Å) are discussed. Ultraviolet radiation associated with flares and plages are considered. A comparison is made between the ultraviolet spectra of the quiet and active sun. (C.E.S.)

**28211** RADIO EVIDENCE FOR SOLAR CORPUSCULAR EMISSION. A. Maxwell, R. J. Defouw, and P. Cummings (Harvard Radio Astronomy Station, Fort Davis, Tex.). Planetary Space Sci., 12: 435-49(May 1964).

The relation of solar radio bursts of spectral type IV to the ejection of relativistic and sub-relativistic solar particles, the relation of bursts of types II and IV to the ejection of solar plasma, and radar evidence for quite solar streaming are reviewed. Ejection of relativistic and subrelativistic particles by flares is virtually always accompanied by type-IV radio bursts. The minimum Sun–Earth travel time for these particles is about 20 min. Ejection of plasma from flares accompanied by bursts of types II and IV is considered in terms of subsequent geomagnetic effects. Type IV bursts are highly associated with geomagnetic storms and type II bursts have a small but significant association. The Sun–Earth travel time for the storm plasma is generally 36–48 hr. Type II bursts may possibly be identified with passage through the corona of a large amplitude shock wave, which then propagates outwards through the interplanetary plasma, causing a geomagnetic sudden commencement when it

reaches the earth. The presence of type IV radiation may be indicative of the amount of material transported behind the shock front. Radar observations of the solar corona indicate that at a height of approximately 350,000 km above the photosphere there is a net outward flow of matter at a velocity of about 16 km/sec. This velocity is consistent with Parker's hydrodynamic theory, for coronal temperatures of the order of $10^{6}$°K. (auth)

**28212** STREAMING OF SOLAR PARTICLES BETWEEN SUN AND EARTH. T. Obayashi (Kyoto Univ.). Planetary Space Sci., 12: 463-85(May 1964).

Enhanced electromagnetic and corpuscular emissions during solar flares and their geophysical effects are discussed. Properties of the solar particles and radiation, their propagation through interplanetary space, and their energy distributions are considered. The behavior of solar plasma flows is also discussed. (C.E.S.)

**28213** M-REGIONS. C. W. Allen (London Univ.). Planetary Space Sci., 12: 487-94(May 1964).

The properties of solar M-regions, that is, regions of the solar atmosphere that emit the particles that cause recurrent geomagnetic storms, are discussed. These regions are somewhat hypothetical solar features and are made evident only by their terrestrial effects. (C.E.S.)

**28214** THE SUN AND INTERPLANETARY PLASMA. E. R. Mustel (Astronomical Council, Academy of Sciences, USSR). Proc. Intern. Space Sci. Symp., 4th Warsaw, 1963, 77-88(1964).

The latest results in the field of investigation of interplanetary plasma are reviewed. Investigations carried out of late fully confirm earlier conclusions that the principal and continuously acting source of interplanetary gas is the Sun and that this gas moves away from the Sun with supersonic velocities of the order of a few hundreds kilometers per second. A very important property of the interplanetary gas is that it carries in it frozen-in magnetic fields of solar origin. Besides, all investigations confirm the conclusions that practically there is no stationary gas in interplanetary space. Quiet undisturbed parts of the Sun as well as its active regions are the source of interplanetary gas. In each case the process of the outflow of gases from the Sun has its peculiarities. Therefore these cases should be considered separately. (auth)

**28215** EMISSION OF EXTREME ULTRAVIOLET RADIATION FROM SOLAR CENTERS OF ACTIVITY. W. M. Neupert (Goddard Space Flight Center, Greenbelt, Md.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 730-40 (1964).

Line emissions at 284, 304, and 335 Å in the solar extreme ultraviolet spectrum observed by OSO-1 were compared with 2800 Mc emission and other indicators of solar activity. Increase in these ultraviolet fluxes can be localized to active regions on the solar disk. Changes in the intensities of the lines are discussed in terms of changes in electron temperature and electron density of the active regions. Certain assumptions made in the calculation of a coronal electron temperature from the relative populations in two stages of ionization of an element are examined, with the conclusion that this calculation may not be valid for the particular case of the solar corona, yielding a fictitiously low value if there is an outward expansion of ions from the base of the corona into a region of higher electron temperature. A non-equilibrium formulation for the distribution of ions is presented which may better describe the actual ion distribution in the corona. An approximate calculation shows that an average radial velocity, outward, and small compared with the average thermal velocity of the ions, is sufficient to explain the observed increase in height of the maxima of emission of the Fe ion sequence with increasing stage of ionization in the undisturbed corona. (auth)

**28216** VARIABILITY OF THE SOLAR X-RAY SPECTRUM BELOW 15 Å. J. L. Culhane (London Univ.), A. P. Willmore, K. A. Pounds, and P. W. Sanford. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 741-58(1964).

Over 150 low resolution x-ray spectra obtained during the first three week period of satellite Ariel were reduced. These measurements, together with those of a series of rocket flights in the period 1959-63, illustrate the variations of the short wavelength tail of the solar x-ray spectrum in both intensity and spectral slope, under non-flare and flare-active conditions. Typical non-flare and flare-enhanced spectra are given. It is shown that the difficulty in describing the measured intensity of non-flare x rays in this short wavelength band, by the emission from a thermalized coronal plasma, may be removed by consideration of both line and continuum radiations from one or more discrete hot regions in the corona. The x-ray enhancement associated with many chromospheric flares may also be interpreted as the thermal emission of a localized hot region, though the variability in the x-ray emission from one flare to another is quite marked. Three flares are described in detail, and of these, two appear to be of this simple thermal type. In the third flare an unusually rapid enhancement or x-ray burst occurs about 20 minutes after the flare commencement. The spectral and time development of this burst are described, and the excellent correlation with an impulsive microwave burst and with the onset of the ionospheric effects are noted. The possibility of both microwave and x-ray bursts having a non-thermal origin are discussed. (auth)

**28217** SPECTRUM OF SOLAR X-RAY EMISSION FROM 2-20 kev DURING SUBFLARE ACTIVITY. T. A. Chubb, H. Friedman, and R. W. Kreplin (Naval Research Lab., Washington, D. C.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 759-67(1964).

Three sounding rockets were launched with proportional counters to measure the spectral energy distribution of solar x rays from 2-20 kev. One rocket was fired when the sun was quiet; the remaining two when the activity was characterized by subflares. The spectrum of the quiet sun fell rapidly and monotonically from 2 to 11 kev. From the slope of the spectrum for energies up to 4 kev, a temperature of about $10^{7}$ °K was derived. Over the same range, the two flights during subflare activity gave similar results but departed markedly from the quiet spectrum at higher energies. Above 4 kev, the flux rose to a maximum near 10 kev in one case and 12 kev in the other, and then declined rapidly toward zero near 16 kev. The presence of this emission peak may be evidence of an intensification of line emission or recombination radiation associated with Fe XXV and XXVI. (auth)

**28218** SPECTRAL ANOMALIES ASSOCIATED WITH THE EXTRAORDINARY X-RAY EMISSION RECORDED BY THE SR-1 SATELLITE ON AUGUST 7, 1960. Zdeněk Švestka (Czechoslovak Academy of Sciences, Ondřejov). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 768-70 (1964).

On August 7, 1960, the SR-1 satellite recorded the highest enhancement of x-ray emission from the Sun which could be ascribed to a small flare situated close to the eastern solar limb. The spectrum of that flare photographed

by a flare spectrograph was conspicuous by a striking central absorption in the Balmer lines up to the $H_8$ and by an anomaly of the metal line intensities. Both these effects were due to an increased absorption above the flare along the line-of-sight. One can suppose that the density of chromospheric and coronal gas above the active region was increased by a factor 3 or 4 in two days or more, which could produce both the spectral anomalies observed as well as the extraordinary x-ray emission enhancements recorded at flares which appeared in that region on August 6 and 7, 1960. (auth)

**28219** SOLAR X-RAYS: SLOW VARIATIONS AND TRANSIENT EVENTS. W. A. White (Goddard Space Flight Center, Greenbelt, Md.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 771-9(1964).

Solar x-ray flux integrated over the interval 0.1–10 Å was measured from the OSO–1 satellite in early 1962 using a xenon-filled ion chamber with a thin beryllium window. A slowly-varying component of x-ray flux was observed which correlates well with the slowly varying component of 2800 Mc solar radiation, and which can be accounted for by localized sources having the same horizontal extent as Ca plages with thicknesses proportional to their diameter; and having an electrom temperature of about $2.8 \times 10^6$ °K and an electron density of about $5 \times 10^9$ electrons per $cm^3$. A further conclusion is that for these conditions the ratio of line emission to continuum emission is at least 10:1 and more probably 30:1. In addition to a slowly varying component, transient events (x-ray flares) lasting from 10 minutes to a few hours were frequently observed. Correlations with H–$\alpha$ flares, with SID's and with 2800 Mc transients were investigated; the results show that as an indicator of local solar activity, the OSO–1 x-ray experiment was more sensitive by a large factor than indicators based on ionospheric effects or than indicators based on observations of solar flux in visible or radio wavelengths. X-ray flares were frequently observed to be associated in groups possessing a characteristic pattern; the implications are discussed. (auth)

**28220** GEOPHYSICAL CHARACTERISTICS OF THE PROTON FLARES. A. C. Dvorjashin. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 780-4(1964).

The configuration of magnetic fields and the motion of plasma and fields in the solar active region where proton flares occur, the spectral characteristics of proton flares, radio outbursts, x-ray emission, and geophysical phenomena associated with proton flares are discussed. (C.E.S.)

**28221** ON THE FORCE-FREE MAGNETIC FIELD IN THE ACTIVE REGIONS OF THE SOLAR CHROMOSPHERE. B. A. Iospha, E. I. Mogilevskii, and W. N. Obridko (Inst. of Terrestrial Magnetism, Ionosphere, and Radioactive Propagation, Moscow). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 789-96(1964).

The local magnetic fields records taken at the height of the chromosphere ($H_\beta$) with a solar tower telescope magnetograph made it possible to detect considerable magnetic fields (about 150 gauss) in some places in the chromosphere above active regions. These magnetic fields were not connected directly with magnetic fields of the photosphere. Extraordinarily powerful magnetic fields (some hundred gauss) were observed in the prominence associated with a flare. It is clear from the well-known considerations that such powerful local magnetic fields in the chromosphere must have force-free (or quasi force-free) structure. It is shown that magnetic fields in chromospheric hills can not be homogeneous. They can not be condensations of magnetohydrodynamic waves of large scale that are propagating from the photosphere. Nor can such magnetic hills in the chromosphere be the consequence of a dynamo-effect of the whirl motions of chromospheric plasma in photospheric field. Calculations show that isolated magnetic hills in chromosphere can have a force-free magnetic field. A satisfactory agreement of a calculated model of a force-free magnetic field with the observed distribution of field strength was achieved. The stability of the system of currents associated with the force-free magnetic field was estimated. The possible occurrence of nonstationary changes in these magnetic field configurations in active regions is noted, particularly, by the generation of corpuscular geoactive streams with force-free magnetic fields. (auth)

**28222** VELOCITY DISTRIBUTIONS OF THE INTERPLANETARY PLASMA DETECTED BY EXPLORER 10. F. Scherb (Massachusetts Inst. of Tech., Cambridge). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 797-818(1964). (TID-19867)

Plasma data obtained from Explorer 10 were analyzed in detail for information on the distribution of positive ion velocities in the plasma. The observed signals are compared with theoretical curves computed under the assumptions that the positive ions are protons and that the velocity distribution is a combination of a Maxwellian distribution characterized by a temperature T, and a bulk motion with a velocity $v_0$. Since the Explorer 10 plasma probe did not provide much information on the average direction of motion of the ions with respect to the equatorial plane of the satellite, this direction was left as an adjustable parameter in the calculations, in addition to T and $v_0$. (auth)

**28223** THE DISTRIBUTION OF INTERPLANETARY PARTICLES. T. R. Kaiser (Univ. of Sheffield, Eng.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 821-7 (1964).

A spatial density distribution of interplanetary dust is derived from meteor, accretion, and zodiacal light data which extends from the larger meteoroids to particles of a micron or less in size. Satellite impact data lead to a different distribution and to much higher spatial densities of the smaller particles. It is concluded that they refer to a cloud of particles in geocentric orbits which probably is the result of capture from the zodiacal cloud. (auth)

**28224** ON THE INTERPLANETARY GAS EXTERIOR TO THE ORBIT OF EARTH. J. C. Brandt (Kitt Peak National Observatory, Tucson, Ariz.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 828-33(1964).

The general properties of the interplanetary plasma at distances greater than 1 AU from the sun are discussed on the basis of the available evidence. Of particular importance is the location of the region of transition from the solar wind to a solar breeze. Evidence is summarized which indicates that the transition occurs rather close to the sun probably near 2 AU. (auth)

**28225** THE ROLE OF RADIO ASTRONOMY IN SPACE RESEARCH. S. Gorgolewski (Nicholas Copernicus Univ., Torun, Poland). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 852-7(1964).

The solar radio astronomy's part in solar research, solar-terrestrial relations and solar influence on space conditions are described. Results of investigations into the influence of enhanced solar radiation on 127 Mc on geomagnetic storms are presented. It is shown that the arrival of charged particles into the space as well as ensuing magnetic storms can be forecast with high probability with 1-3

days warning time. The radio astronomy technique of observations of the influence of solar plasma in the interplanetary space is reviewed. It is using the radio sources occultations by the solar corona at distances up to more than 100 solar radii. Three unusual events of abnormal propagation of radio waves in the corona were observed during the occultations of the Taurus A radio source in 1961 and 1962. These observations support the view that the solar corpuscular radiation influences radio wave propagation at distances of tens of million km from the Sun. Three base occultations in 1959 enabled extensive measurements of the direction of the interplanetary magnetic fields. These fields predominantly radial to the Sun are at times considerably disturbed due to the influence of enhanced solar corpuscular emission. Similar variations were reported by other observers and confirmed by the Pioneer V space craft. The influence of the solar, galactic, and radio noise on the cosmic radio communication is also considered. (auth)

**28226** GALACTIC X-RAY EMISSION DUE TO SUPRATHERMAL PARTICLES. Satio Hayakawa and Masaru Matsuoka (Nagoya Univ., Japan). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 960-5(1964).

Possible mechanisms of x-ray emission from sources outside the solar system are discussed on the basis of the probable existence of strong sub-cosmic rays in interstellar space. These non-relativistic particles excite K x-rays of medium weight atoms and produce knock-on electrons which emit inner bremsstrahlung. The x-ray intensity thus expected is 0.2 $cm^{-3} \cdot sec^{-1} \cdot st^{-1}$ towards the Galactic center and is much weaker than that observed by Giacconi et al., if the sub-cosmic ray intensity is assumed to be about one hundred times stronger than the intensity of relativistic particles, but it may give the x-ray intensity comparable to that due to the synchrotron radiation suggested by Clark. (auth)

**28227** X-RAY ASTRONOMY. S. Bowyer (Naval Research Lab., Washington, D. C.), E. T. Byram, T. A. Chubb, H. Friedman, and E. O. Hulburt. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 966(1964).

An attempt was made to observe x-ray emission from galactic sources. Preliminary analysis of the telemetered data revealed a relatively strong x-ray source in the direction of Scorpius. The observed counting rate was 400 counts $sec^{-1}$ above a background of 25-40 counts $sec^{-1}$. (C.E.S.)

**28228** NUCLEAR REACTIONS IN OUTER SPACE. J. A. Surkov (Inst. of Geochemistry and Analytical Chemistry, Academy of Sciences, USSR). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 989-94(1964).

The data concerning the chemical composition and radioactivity of iron meteorites are given. The character of nuclear processes, which occur in iron meteorites under the action of cosmic ray is compared with nuclear reactions arising under the bombardment of iron by protons of high energy on the accelerators. The quantity of cosmogenous isotropes in iron meteorites and the average effective energy of cosmic protons are estimated. (auth)

**28229** NATURE OF THE RADIO GALAXY CYGNUS A. N. S. Kardashev (Sternberg Astronomical Inst., USSR). Soviet Astron. AJ (English Transl.), 7: 740-7(May-June 1964).

Experimental data on the ratio of the radio spectrum of Cygnus A to that of Cassiopeia A are compared with the spectrum of Cygnus A as predicted by various models. The regions of synchrotron radiation in the radio galaxy Cygnus A apparently represent two clouds which have relativistic particles and a magnetic field and which are receding from their parent galaxies at nearly the velocity of light. The sources are estimated to be 0.18 to $1.30 \times 10^8$ years old. (auth)

**28230** NATURE OF JETS IN RADIO GALAXIES. I. S. Shklovskii (Shternberg Astronomical Inst., USSR). Soviet Astron. AJ (English Transl.), 7: 748-54(May-June 1964).

The relativistic electrons in the jet of NGC 4486 can not have a secondary origin. The relativistic-proton and heavy-nucleus content of radio galaxies seems to be small, substantially reducing the energy of the relativistic particles and magnetic fields. The NGC 4486 jet has a regular magnetic field which can be modeled by a curved (or helical) tube of force. In this situation, the relativistic electrons generated in the nuclear region and moving outward should be emitted anisotropically, increasing their lifetime and explaining the nonuniform photometric structure of the jet. The "onesidedness" of some jets is naturally explained in this way. The optical emission of the faint appendage of NGC 5128 and the nebula surrounding the two bright condensations of Cygnus A is probably synchrotron radiation. (auth)

**28231** ESTIMATE OF THE ELECTRON DENSITIES IN STELLAR CHROMOSPHERES. M. A. Livshits (Inst. of Geomagnetism, Ionosphere, and Radio Wave Propagation, Academy of Sciences, USSR). Soviet Astron. AJ (English Transl.), 7: 813-17(May-June 1964).

Acoustical theories on the heating of the solar chromosphere and corona are extended to stellar chromospheres. The emission measures and the electron densities of the stellar chromospheres are computed on the assumption that the energy flux of acoustic waves and the energy carried off by radiation are equal. The most powerful chromospheres should be observed in the case of F5 giants and early supergiants. If active and undisturbed solar regions are considered as independent atmospheres, then it may be shown that a 30% increase in convection speed is required to account for the enhanced electron density in the active region (where the increase is about a factor of three). (auth)

**28232** GAMMA AND X-RAYS RELATED TO GALACTIC AND METAGALACTIC COSMIC RAYS. V. L. Ginzburg and S. I. Sirovatskii (Lebedev Inst. of Physics, Leningrad). Zh. Eksperim. i Teor. Fiz., 46: 1865-79(May 1964). (In Russian)

The intensity of $\gamma$ rays produced as a result of various processes of interaction between cosmic rays (including the electron component) and the interstellar and intergalactic gas or thermal radiation is calculated. The main contribution to the $\gamma$-ray intensity is from scattering of relativistic electrons on thermal photons although $\gamma$ rays from the decay of $\pi^0$ mesons and electron bremsstrahlung may also be important. Comparison of the calculations with the experimental data indicates that the intensity of the electron component of cosmic rays in the Metagalaxy is at least one and a half or two orders smaller than that in the Galaxy. The region of ultrahigh-energy electrons which could yield magnetic bremsstrahlung x rays and produce atmospheric showers with an anomalously small number of mesons is discussed. (auth)

**28233** ASPECTS OF THE RADIATION COOLING OF A HOT GAS. George William Curtis. Thesis, Boulder, Colo., Univ. of Colorado, 1963. 171p.

The equations governing the radiation cooling of a gaseous system are presented and applied to simple models in

the temperature range from a few thousand to a million degrees. The phenomena investigated are principally those occurring in systems that radiate away their limited supply of internal energy following the removal of the energy input that maintained them in equilibrium. The systems under study have only one atomic constituent plus electrons. The atoms making up the gas are limited to two levels (two-bound-levels or a bound level plus a continuum) and these levels produce the only radiation emitted by the system. The radiating systems selected are self luminescent and either optically thin ($\tau \ll 1$) or optically thick ($\tau > 1$). For an optically thin system cooling through line radiation, no departure from equilibrium will be observed unless the rate of collisional excitation can produce appreciable cooling in time intervals smaller than $1/A_{21}$ seconds. $A_{21}$ is the coefficient of spontaneous emission. Rough computations of the energy budget of a proton-electron plasma containing idealized impurities show that unless LTE is assumed radiation cooling alone cannot produce the observed relaxation time. For optically thin systems cooling through free-bound radiation, large departure from equilibrium may occur during the cooling process, if the system, initially ionized, is allowed to cool through the temperature range where radiative recombination rates are of the same order of magnitude as the rates of collisional excitation. One set of temperature versus optical depth curves are presented for various time intervals during the line radiation cooling of an optically thick system. (Dissertation Abstr., 24: No. 11, 1964)

## Atomic Physics

*Refer also to abstract 28442.*

**28234** (AD-418676) AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF RADIATION ON THE PROPAGATION OF ELECTROMAGNETIC SIGNALS IN AIR. Quarterly Progress Report No. 4, April 1–June 30, 1962. M. N. Hirst, J. W. Blaker, and P. N. Eisner (Dewey (G. C.) and Co., Inc., New York). June 30, 1962. Contract DA-36-039-SC-87315. 22p. (R-146-4)

Experiments designed to study the interactions of 1.5-Mev electron beams with electromagnetic waves in air were conducted in a resonant cavity operating in the $TE_{011}$ mode. The thermalization and recombination characteristics of the electrons and ions produced by the electron bombardment of the air were also studied. (T.F.H.)

**28235** (AD-419133) AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF RADIATION ON THE PROPAGATION OF ELECTROMAGNETIC SIGNALS IN AIR. Quarterly Progress Report No. 6, October 1–December 31, 1962. M. N. Hirst and P. N. Eisner (Dewey (G. C.) and Co., Inc., New York). Dec. 31, 1962. Contract DA-36-039-SC-87318. 26p. (R-146-6)

A technique has been developed for measuring thermal electron processes in gases in a steady-state experiment, obviating the need to make transient measurements in the afterglow. 1.5-Mev electrons from an accelerator irradiate the gas uniformly, producing ions and secondary electrons, which are rapidly thermalized by gas collisions. The gas is contained in a 710 liter cylindrical r-f cavity resonant in the $TE_{011}$ mode at 390 Mc to permit microwave diagnostics. The large cavity size minimizes wall effects, and ultrahigh vacuum techniques safeguard gas purity. Preliminary measurements of steady-state ionization made in oxygen will be presented. The data yield an electron removal process linear in electron density, and varying with the square of the gas pressure. This is identified as three-body attachment of electrons to $O_2$ in view of the agreement with published values for this rate coefficient. (auth)

**28236** (EUR-1815.d,f,e) ACCELERATOR TARGETS DESIGNED FOR THE PRODUCTION OF NEUTRONS. (Liege. Universite). 1964. 188p.

In English, French, and German.

Accelerator targets designed for the production of mono- or polyenergetic neutrons were studied. The discussion related mainly to tritium targets, with a view to their most efficient use and to the improvements to be made in them in order to increase their life and their yield. (auth)

**28237** (R64SD28) PHOTO-IONIZATION CONTINUA. I. THE BOUND FREE CONTINUA OF NEGATIVE IONS. R. G. Breene, Jr. (General Electric Co. Missile and Space Div., Valley Forge Space Technology Center, King of Prussia, Penna.). Apr. 1964. 15p.

The photoionization or bound free continuum of the negative oxygen ion is considered. The effects of correlation in the bound function and the form of the operator on a treatment of the phenomenon are directly demonstrated while the effect of polarization in the free function is pointed out. For the representations of the operator used, the asymptotic form of the free function is essentially equivalent to the precise form. An ab initio calculation for the cross section yields results some thirty percent greater than experiment and of the proper form. (auth)

**28238** (ANL-Trans-25) TRIPLET SPLITTING OF ATOM TERMS WITH TWO VALENT 2p-ELECTRONS. A. P. Yutsis, V. K. Shugurov, and G. K. Tsyunaytis. Translated by Elmar K. Wilip (Argonne National Lab., Ill.), from Zh. Eksperim. i Teor. Fiz., 23: 517-24(1952). 11p.

Formulas for the triplet splitting of atomic terms with two valent 2p-electrons were derived. The triplet splitting of atoms of the helium type in the $2p^2$ configuration and of the beryllium type in the configuration $1s^2\ 2p^2$ was determined by using analytical wave functions. The triplet splitting of the beryllium atom in the configuration $1s^2 2p^2$ as well as the splitting of the basic configuration of the neutral carbon atom and doubly ionized oxygen atom were determined by means of single-electron wave functions, which represented the solutions of the equations for the self-consistent Fock field. The theoretical results obtained were compared with the experimental data. (auth)

**28239** VIBRATIONAL FREQUENCY PERTURBATIONS IN THE RAMAN SPECTRUM OF COMPRESSED GASEOUS HYDROGEN. A. D. May, G. Varghese, J. C. Stryland, and H. L. Welsh (Univ. of Toronto). Can. J. Phys., 42: 1058-69(June 1964).

The frequencies of the Q(J) lines of the fundamental Raman band of compressed hydrogen gas were measured with high spectral resolution for a series of densities from 25 to 400 Amagat units at 300°K and 85°K. The frequency shifts are expressed as a power series in the gas density. The linear coefficient at a given temperature has the form $a_J = a_i + a_c(n_J/n)$, where $a_i$, constant for all the Q lines, can be interpreted in terms of isotropic intermolecular forces, and $a_c(n_J/n)$, proportional to the relative population of the initial J level, arises from the inphase coupled oscillation of pairs of molecules. The temperature variation of $a_i$ is analyzed on the basis of the Lennard-Jones intermolecular potential and the molecular pair distribution function. The repulsive overlap forces and

the attractive dispersion forces give, respectively, positive and negative contributions to $a_1$, which can be characterized by the empirical parameters $K_{rep}$ and $K_{att}$. The values of $K_{att}$ and $a_c$ are in good agreement with calculations based on the polarizability model of the dispersion forces. The relation of the results to the Raman frequency shifts in solid hydrogen is discussed. (auth)

**28240** VIBRATIONAL ISOTOPE SHIFTS OF ABSORPTION BANDS OF $N_2$ IN THE SPECTRAL REGION 720-830Å. Masaru Ogawa (Univ. of Southern California, Los Angeles). Can. J. Phys., 42: 1087-96(June 1964).

Using a normal-incidence vacuum spectrograph with a 3-m concave grating, the absorption spectra of $^{14}N_2$ and $^{15}N_2$ in the 720–830 Å region were investigated. From the vibrational isotope shifts, it was confirmed that the previous assignment given by Ogawa and Tanaka for the Rydberg series converging to the $A^2\Pi_u$ state of $N_2^+$ was correct. The observed series limits converging to the $A^2\Pi_{u,1/2}$ state of $^{15}N_2^+$ are 134735(0,0), 136540(1,0), 138320(2,0), and 140070(3,0) $cm^{-1}$. The observed vibrational isotope shifts at the series limits in both Rydberg series converging to the $A^2\Pi_u$ and the $X^2\Sigma_g^+$ states of $N_2^+$ agree with those values calculated from the known vibrational constants of the $A^2\Pi_u$, and the $X^2\Sigma_g^+$ states of $^{14}N_2^+$ and the $X^1\Sigma_g^+$ state of $^{14}N_2$. In addition to the Rydberg series, four new progressions tentatively were identified. The observed vibrational quanta of the upper states of these progressions are almost the same, and are, moreover, almost the same as those of the $A^2\Pi_u$ state of $N_2^+$. (auth)

**28241** THE MASS SPECTROMETRIC DETECTION OF HIGHLY EXCITED LONG-LIVED STATES OF NOBLE GAS ATOMS. V. Cermak and Z. Herman (Inst. of Physical Chemistry, Czechoslovak Academy of Sciences, Prague). Collection Czech. Chem. Commun., 29: 953-9(Apr. 1964). (In German)

Experimental data indicated that an atomic beam of noble gases, excited by electron impact, contains, in addition to atoms in low-lying excited metastable states, atoms in long-lived excited states whose excitation energy is close to the ionization potential. The atoms in these states could be detected by their ionization caused by interaction with metallic surfaces and by ionizing reactions in collisions with polyatomic molecules. (auth)

**28242** A GENERAL DISCUSSION ON THE STRUCTURE OF ELECTRONICALLY EXCITED SPECIES IN THE GAS-PHASE, 2ND AND 3RD APRIL, 1963. Discussions Faraday Soc., No. 35, 1-239(1963).

Twenty-three papers are included. Separate abstracts were prepared for 7. One paper was previously abstracted for NSA; see abstract 18: 22027. (M.J.T.)

*For abstracts of individual papers see: 27383, 27384, 28385, 27386, 27479, 27512, and 28243.*

**28243** ELECTRON-IMPACT SPECTROSCOPY. Aron Kuppermann and L. M. Raff (Univ. of Illinois, Urbana). Discussions Faraday Soc., No. 35: 30-42(1963).

A spectrometer was devised for determining electronic energy levels of molecules by inelastic scattering of low-energy electrons. It permits the detection of optically forbidden electronic transitions as clearly as optically allowed ones in a routine manner. The spectrometer was used to obtain excitation spectra for helium, argon, hydrogen, and ethylene. For the first three of these substances, the spectra agree with previous experiments. For ethylene, in addition to optically allowed transitions, two forbidden ones occur at about 4.6 and 6.5 ev. Variations of peak heights with incident electron-beam energy suggest that the first corresponds to a triplet state but that the second does not. (auth)

**28244** THEORY OF THE DEPENDENCE OF NUCLEAR MAGNETIC RELAXATION ON THE ABSOLUTE SIGN OF SPIN-SPIN COUPLING CONSTANT. Hiroshi Shimizu (Chiba Univ., Japan). J. Chem. Phys., 40: 3357-64(June 1, 1964).

It is theoretically shown that the nuclear relaxation times and the saturation parameter of each component line of two-spin spectrum depend on the sign of the spin-spin coupling constant J. Then it is suggested that the absolute sign of J can be determined through measurement of the relaxation times or saturation parameters. The experimental conditions are discussed, taking two-spin systems of $^{13}C-{}^1H$, $^{13}C-{}^{19}F$, $^1H-{}^{19}F$, and $^1H-{}^{31}P$ as examples. (auth)

**28245** DIAMAGNETIC NUCLEAR SHIELDING CONSTANTS FOR NEUTRAL ATOMS. R. A. Bonham and T. G. Strand (Indiana Univ., Bloomington). J. Chem. Phys., 40: 3447-8(June 1, 1964).

The diamagnetic shielding constants for the neutral atoms from Z = 2 to 100 were calculated using a Hartree-Fock electron density function for Z = 2 to 36 and a Thomas-Fermi-Dirac electron density function for Z = 2 to 100. The results (presented) are in good agreement with the Hartree-Fock calculations of Rustgi and Tiwari. (D.C.W.)

**28246** CROSS SECTIONS FOR THE SINGLE CHARGE TRANSFER OF DOUBLY-CHARGED RARE-GAS IONS IN THEIR OWN GASES. G. R. Hertel and W. S. Koski (Johns Hopkins Univ., Baltimore). J. Chem. Phys., 40: 3452-3 (June 1, 1964).

The cross sections for single charge transfer of $Ar^{2+}$, $He^{2+}$, $Kr^{2+}$, $Ne^{2+}$, and $Xe^{2+}$ in their parent gases were determined as a function of ion velocity. The results are compared with the data of Flaks and Fedorenko. The velocity at which the cross section is a maximum increases in going from Xe to He. At any given velocity < the velocity for maximum cross section, the cross section is greatest for Xe and smallest for He. (D.C.W.)

**28247** APPROXIMATE SERIES SOLUTIONS OF NON-SEPARABLE SCHRÖDINGER EQUATIONS. I. MATHEMATICAL FORMULATION. Arthur A. Frost (Northwestern Univ., Evanston, Ill.). J. Chem. Phys., 41: 478-82(July 15, 1964).

A series solution method is developed that is a generalization of the method used by Pekeris for helium-atom calculations. It is equivalent to the linear variation method but requires few, if any, matrix component integrals to be evaluated. The method is illustrated by an application to the s states of the hydrogen atom. (auth)

**28248** APPROXIMATE SERIES SOLUTIONS OF NON-SEPARABLE SCHRÖDINGER EQUATIONS. II. GENERAL THREE-PARTICLE SYSTEM WITH COULOMB INTERACTION. Arthur A. Frost, Mitio Inokuti, and John P. Lowe (Northwestern Univ., Evanston, Ill.). J. Chem. Phys., 41: 482-9(July 15, 1964).

The series solution method developed by Pekeris for the Schrödinger wave equation of two-electron atoms was generalized to handle any three particles with Coulomb interaction. Calculations were carried out with wavefunctions through the sixth degree which result in a linear combination of 84 terms for the unsymmetrical case. Systems for which numerical results are given are: the hydride ion with nuclear motion, the trielectron ($e^+e^-e^-$) or positronium ion, the positron–hydrogen atom interaction ($e^+e^-p^+$),

and the mu-mesonic isotopic hydrogen molecule-ion ($p^+\mu^-d^+$). (auth)

**28249** APPROXIMATE SERIES SOLUTIONS OF NON-SEPARABLE SCHRÖDINGER EQUATIONS. III. B MATRIX METHOD. Arthur A. Frost, Donald K. Harriss, and Jeffrey D. Scargle (Northwestern Univ., Evanston, Ill.). J. Chem. Phys., 41: 489-94(July 15, 1964).

The series solution B matrix method is applied to systems of one and two electrons with wave functions expressed in interparticle coordinates. The application to more complicated systems is considered. (auth)

**28250** ANGULAR DEPENDENCE OF THE SCATTERING OF METASTABLE HELIUM ATOMS IN HELIUM AND NEON. H. L. Richards and E. E. Muschlitz, Jr. (Univ. of Florida, Gainesville). J. Chem. Phys., 41: 559-65 (July 15, 1964).

A molecular beam method was used to perform scattering experiments with an atomic beam of metastable helium atoms in helium and neon. The atomic beam, in which some of the atoms were excited by electron impact, was passed through a scattering chamber containing gas at low pressures and subsequently detected by electron ejection from gold surfaces. The $2^1S$ to $2^3S$ helium atom ratio in the beam was determined using an inhomogeneous magnetic field. Total collision cross sections for the scattering of both metastable helium atoms in helium and neon were measured as a function of the angular resolution of the apparatus. Angular scattering coefficients in the angular range 7°–25° were calculated. In both gases the scattering at these angles of $2^3S$ helium was larger than $2^1S$ helium. These differences can only be caused by differences in the interaction forces between the colliding particles. The results are consistent with the higher interaction of triplet metastable atoms with ground-state atoms calculated by Buckingham and Dalgarno. Separate measurements of the backward scattering allowed a lower limit of $2 \times 10^{-16}$ cm$^2$ to be set for the He*–He energy-transfer cross section. (auth)

**28251** ATOMIC HYDROGEN PRODUCTION IN ELECTRICAL DISCHARGE. Vaclav Bejšovec (Inst. for Nuclear Research, Czechoslovak Academy of Sciences, Rez). Jaderna Energie, 10: 164-8(May 1964). (In Czech)

Basic physical theory and experimental data on electrical discharges in a hydrogen atmosphere resulting in atomic hydrogen release are summarized. Some designs of dissociators used in sources of polarized particle beams are described. (auth)

**28252** X-RAY SPECTROANALYSIS OF LIGHT ELEMENTS USING $H^3$/Zr AS EXCITING SOURCE. Takashi Tanemura (Rigaku Denki Co., Tokyo). Japan J. Appl. Phys., 3: 208-14(Apr. 1964).

The capability of a device for x-ray spectroanalysis was studied which essentially consists of a $^3$H/Zr source, a helium-filled specimen chamber, and a proportional counter equipped with a thin plastic window. The best results were obtained with a 0.46-mg/cm$^2$ polycarbonate window which allows the transmission of soft x rays below 1 kev, but stops the beta particles emitted from the source and scattered towards the window. It was found that both the x rays and beta particles from the $^3$H/Zr source are effective in exciting the characteristic x rays of light elements (Na, Mg, Al, and Si) and of elements of intermediate atomic numbers (Ti, V, Cr, Mn, Fe, Co, and Ni). The K x-ray intensities for light elements are comparable to or higher than those for elements of intermediate atomic numbers. Two examples are given which illustrate the usefulness of this device in the x-ray spectroanalysis of light elements. (auth)

**28253** FLUORESCENCE YIELD $\omega_{KL}$ OF THE L-SHELL. K. Hohmuth and G. Winter (Zentralinstitut für Kernforschung, Rossendorf, Ger.). Phys. Letters, 10: 58-9(May 15, 1964). (In German)

The average fluorescence yields $\omega_{KL}$ of the L-shell of silver, xenon, and praseodymium were determined. The L-subshells were excited through electron capture and internal conversion. Measurements were made using proportional counters and scintillation counters. (C.E.S.)

**28254** OPTICAL ATOMIC SPECTROSCOPY WITH A VAN DE GRAAFF ACCELERATOR. S. Bashkin (Univ. of Arizona, Tucson), P. R. Malmberg, A. B. Meinel, and S. G. Tilford. Phys. Letters, 10: 63-4(May 15, 1964).

Electronic levels in multiply-ionized atoms excited by passing fast particles through thin foils are investigated. A Van de Graaff accelerator is used to accelerate ions through carbon foils. The beam is made luminescent by interactions in the foil. Light from beams of H, D, He, C, N, O, Ar, Kr, and Xe was analyzed with a grating spectrograph. (C.E.S.)

**28255** NODAL BOUNDARY CONDITION METHOD FOR ATOMIC WAVE FUNCTIONS AND TRANSITION PROBABILITIES. T. M. Helliwell (Harvey Mudd Coll., Claremont, Calif.). Phys. Rev., 135: A325-31(July 20, 1964).

A method is presented for computing valence atomic wave functions and transition probabilities. This method, called here the "nodal boundary condition method," is a modified self-consistent-field approach which makes some use of experimental term values in order to eliminate the need for calculating wave functions for the core electrons. As an application, the method is used to compute eigenvalues, wave functions, and oscillator strengths for thirteen atoms and ions having two valence electrons. (auth)

**28256** PARTIAL ATOMIC AND IONIC STOPPING POWERS OF GASEOUS HYDROGEN FOR HELIUM AND HYDROGEN BEAMS. J. Cuevas, M. Garcia-Munoz, P. Torres, and S. K. Allison (Univ. of Chicago). Phys. Rev., 135: A335-45(July 20, 1964).

The partial stopping power of a target material for an ion or an atom is the energy lost per target particle per cm$^2$ in all types of collisions in which the ion or the atom is the projectile, with the exception of those collisions in which the projectile leaves with its charge changed. Partial atomic stopping powers of target gases for atoms are measured by imposing a strong transverse magnetic field on the stopping cell. For partial ionic stopping-power measurements, the ion beam is held in a circular orbit, closely defined by vanes and slits, as it traverses the stopping cell. The partial stopping powers $\epsilon_0$ (for $He^0$ traversing $H_2$ gas), $\epsilon_1$ (for $He^+$), $\epsilon_2$ (for $He^{2+}$) were measured in the kinetic energy range 40 to 460 kev, and new measurements of the ordinary, or total stopping power of $H_2$ gas for helium from 40 to 220 kev were made. Using the known charge composition of He beams in $H_2$, it is possible to deduce the fraction of the stopping power losses due to charge changing collisions, and this varies from 37% at 140 kev to 27% at 400 kev. At 120 kev, the total energy loss in completing the charge changing cycle $He^+ \rightarrow He^0 \rightarrow He^+$ is 95 ± 9 ev, rising to 117 ± 10 at 160 kev. (auth)

**28257** FREDHOLM DETERMINANTS APPLIED TO ELECTRON-HYDROGEN SCATTERING. Gerald L. Nutt (Lockheed Missiles and Space Co., Palo Alto, Calif.). Phys. Rev., 135: A345-52(July 20, 1964).

The properties of the Fredholm determinant for the electron-hydrogen atom system are discussed. These properties are used to derive formulas for the elastic-scattering phase shifts. S- and P-wave phase shifts are calculated for low energies and the results are compared with other recent calculations. Exchange effects are fully accounted for in the formalism, and a formula is given for the scattering amplitude when two exit channels are present. (auth)

**28258** TEMPERATURE DEPENDENCE OF HELIUM METASTABILITY EXCHANGE CROSS SECTION. F. D. Colegrove, L. D. Schearer, and G. K. Walters (Texas Instruments Inc., Dallas). Phys. Rev., 135: A353-7(July 20, 1964).

The cross section for exchange of metastability in collisions between $He^3$ atoms in the ground ($1^1S_0$) state and metastable ($2^3S_1$) state was measured as a function of temperature by optical pumping techniques. The exchange cross section decreases from about $5.5 \times 10^{-16}$ $cm^2$ at 500°K to less than $10^{-17}$ $cm^2$ at 4.2°K. These results suggest a thermally activated exchange process in qualitative agreement with the predicted existence of a long-range repulsive interaction between metastable and ground-state helium atoms as proposed by Buckingham and Dalgarno. (auth)

**28259** CHARACTERISTIC X-RAY PRODUCTION IN THE M SHELL OF $_{60}Nd$, $_{62}Sm$, $_{64}Gd$, $_{65}Tb$, $_{66}Dy$, AND $_{67}Ho$ BY 25- TO 100-kev PROTONS. J. M. Khan, D. L. Potter, and R. D. Worley (Univ. of California, Livermore). Phys. Rev., 135: A511-13(July 20, 1964). (UCRL-7669)

Characteristic M-shell x rays produced when protons of 25- to 100-kev energy are stopped in thick targets of Nd, Sm, Gd, Tb, Dy, and Ho were observed by proportional-counter detection. The energy of the x rays ($M_\alpha$) varied from 980 to 1360 ev. The quantities obtained in the experiment were the thick-target yields (x rays per proton) and estimates of the x-ray production and ionization cross sections. With a fluorescence yield of 0.01, the ionization cross sections fall between $10^{-24}$ and $10^{-21}$ $cm^2$. (auth)

**28260** EXCITATION OF HELIUM BY HELIUM IONS. F. J. de Heer and J. van den Bos (Laboratorium voor Massascheiding, Amsterdam). Physica, 30: 741-4(Apr. 1964).

The excitation of singlet and triplet states of the helium atom by impact of helium ions at 5 to 100 kev was investigated. Absolute excitation cross sections and the degree of polarization of the resulting radiation were determined. (C.E.S.)

**28261** DETERMINATION OF ROTATIONAL RELAXATION TIMES OF HYDROGEN ISOTOPES BY SOUND ABSORPTION MEASUREMENTS AT LOW TEMPERATURES. [PART] I. C. G. Sluijter, H. F. P. Knaap, and J. J. M. Beenakker (Kamerlingh Onnes Laboratorium, Leiden). Physica, 30: 745-62(Apr. 1964).

An apparatus to measure sound absorption at low temperatures is described. Measurements were performed on hydrogen isotopes at 77, 90, and 293°K to determine the excess absorption due to relaxation between the rotational and translational energy states. For p-$H_2$ and o-$D_2$ at 77 and 90°K an absorption curve was found which could be fitted with the theoretical curve of a process with a single relaxation time. Hence in this case the relaxation times could be determined uniquely. The experimental results are discussed and compared with theoretical investigations based on calculations of the cross section for rotational transitions. (auth)

**28262** ANGULAR-DEPENDENT SPUTTERING OF COPPER SINGLE CRYSTALS BY 20 kev NOBLE GAS IONS. J. M. Fluit and P. K. Rol (F.O.M. Laboratorium voor Massascheiding, Amsterdam). Physica, 30: 857-69(Apr. 1964).

Copper single crystals were bombarded with 20-kev $Ne^+$, $Ar^+$, and $Kr^+$ in a 180° isotope separator. Measurements of sputtering yields were made at different angles of incidence of the noble gas ions impinging on the surface of a copper single crystal. Three differently oriented crystals with a (100), (110), and (111) plane as a surface were used. The yield-angle curves show relative minima at incidence angles where the ion beam is aimed along low index crystal directions. The width of the minima and the angle at which a minimum occurs is discussed in terms of a rigid sphere model of the surface region, where the chance of a collision in this region is taken as the most important parameter for the sputtering ratio. This model enables one to derive an effective collision radius from the experimental data. This method yields, for 20-kev $Ne^+$, $Ar^+$, and $Kr^+$-ion bombardment on Cu, effective collison radii of 0.25, 0.29, and 0.24 Å respectively, which is a factor 2.1, 1.7, and 1.0 respectively higher than that obtained from the Bohr theory for the hard sphere approximation. A physical interpretation of these factors indicates that the model is not entirely applicable. (auth)

**28263** THE EMISSION OF FAST SECONDARY ATOMS FROM IONICALLY BOMBARDED COPPER ("REFLECTIONS"). J. M. Fluit, J. Kistemaker, and C. Snoek (F.O.M. Laboratorium voor Massascheiding, Amsterdam). Physica, 30: 870-6(Apr. 1964).

A study was made of the production of fast secondary atoms from copper polycrystalline and single-crystalline targets. The reflected atoms were measured with a secondary emission detector. The targets were bombarded with $Ar^+$ ions, mainly at an energy of 15 kev. By application of pulsed ion beam techniques it was found that the energy distribution of the measured atoms has a sharp maximum at the mean value expected for single elastic biparticle collisions. The total yield of these reflections was measured as a function of the angle of incidence of the ion beam. It increases much faster than the sputtering ratio and reaches a value of more than 1% of the primary ion beam for very oblique incidence. Experiments on a single crystal show the influence of crystal orientation on the reflections. The influence of crystal order is much smaller than the analogous one for sputtering. This shows that the process of sputtering of neutral copper atoms takes place deeper inside the crystal than the emission of fast particles. Most reflected atoms were found at a reflection angle of 70° with the normal, independent of the angle of incidence of the primary ion. The maximum reflection angle will be determined by the surface roughness, which is not strongly dependent on the angle of incidence for polycrystalline targets. An estimate of secondary sputtering due to the reflections and the surface roughness gives a yield in the order of 10% of primary sputtering. (auth)

**28264** MOLECULAR THEORY OF ISOTOPIC CONDENSED SYSTEMS. H. Friedmann (Université Libre, Brussels). Physica, 30: 921-3(Apr. 1964).

The properties of polyatomic isotopic systems are considered. A previous treatment was extended to include electronic and vibrational zero point motions and also to account for the translational and rotational effects of asymmetric molecules. It was assumed that the perturbation of the intramolecular electronic and vibrational motions caused by the intermolecular forces is small, that

quantum effects on the hindered rotation of the molecules in the condensed phase can be described by the first quantum correction to the classical partition function, and that the coupling between the rotational and the internal motions in a free molecule can be neglected. Expressions for the quantum mechanical configuration integral and the effective mass were obtained. (C.E.S.)

**28265** RESONANCE CHARGE EXCHANGE OF NEGATIVE IONS OF THE ALKALI METALS. Yu. F. Bydin (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Eksperim. i Teor. Fiz., 46: 1612-18(May 1964). (In Russian)

Resonance charge exchange of 900- to 2400-ev $Na^-$, $K^-$, $Rb^-$, and $Cs^-$ ions was studied. The cross section for the process, $Q_{pn}$, is of the order of $10^{-14}$ $cm^2$ and increases with decreasing ion velocity v. The electron affinity to Na, K, Rb, and Cs atoms is determined from the slope of the curve $Q_{pn}(v)$ by comparing the results with Firsov's theory. (auth)

**28266** A MULTIPLE ORDER BACKSCATTERING THEORY FOR NORMALLY INCIDENT GAMMA RAY BEAMS. Leonard Richard Stone. Thesis, Cleveland, Case Inst. of Tech., 1963. 315p.

The special problem involving the multiple order backscattering of a collimated, monoenergetic gamma beam incident normally to a dense plane barrier of finite and semi-infinite thickness is examined. The reflected photon flux intensity and the spectral composition were analyzed for a pure Compton scatterer. The scattering effects are described in terms of the following albedos: the differential number and spectral albedos corresponding to a remote observation point; and the integrated number and spectral albedos corresponding to the hemispherical half-space above the barrier. The indicated albedos were developed in terms of separate models for the first order, the second order, and the $n^{th}$ order for $n > 2$. The first order albedos were derived exactly from Compton's scattering formula and the Klein-Nishina cross section formula. The second order albedos were similarly determined exactly for the normally reflected radiation, and approximately for the obliquely reflected radiation. The higher order albedos for $n > 2$ were developed from a mathematical model based on an isotropic scattering law. Predictions of the composite mathematical model were compared with corresponding experimental and Monte Carlo data for $^{198}Au$ (411 kev), $^{137}Cs$ (662 kev), and $^{60}Co$ (1.17 & 1.33 Mev). Conclusions and recommendations for extension of the theory through further research are presented. (Dissertation Abstr., 24: No. 11, 1964)

**28267** A CONFIGURATION-INTERACTION CALCULATION OF WAVE FUNCTIONS FOR CERTAIN STATES OF LITHIUM. Bert Elwood Brown. Thesis, Corvallis, Ore., Oregon State Univ., 1963. 137p.

A configuration-interaction determination of wave functions was made for the $^2S$ and $^2P$ states of lithium, and for the $^1S$ and $^3S$ states of the lithium ion. Two 1s, one 2s, one 3s, and two 2p functions served as starting functions for all four states. Results of the total energy calculations (and percent error) are given. The calculated ionization energy, 0.201 365 AU, is 1.62% high. The $^2P$ calculation is believed to be the first configuration-interaction treatment of this state, and the resulting energy is the most accurate yet achieved. (The energies of the other states were previously computed to a high accuracy, but only with considerably longer expansions.) A larger error of the $^3S$ calculation is probably due to the inadequacy of the description with only seven configurations available. Energies of four excited states of the same symmetries of the others are also presented; their accuracy, however, is somewhat poorer. Methods are discussed for obtaining a good representation of an atomic wave function with as few configurations as possible. Suggestions are made for testing the accuracy of the wave functions in describing other atomic properties. The work demonstrates the feasibility of configuration interaction calculations for light atoms with limited computer facilities. (Dissertation Abstr., 24: No. 11, 1964)

**28268** NON-RELATIVISTIC TIME-DEPENDENT SCATTERING THEORY AND THE COULOMB INTERACTION. John Day Dollard. Thesis, Princeton, N. J., Princeton Univ., 1963. 210p.

The incorporation of Coulomb potentials into the framework of time-dependent non-relativistic scattering theory by giving, for scattering problems involving these potentials, an adequate definition of asymptotic convergence of states is discussed. The concept of asymptotic convergence of states is essential in the time-dependent theory in order to give a physical interpretation of this theory and to give a reasonable definition of the scattering matrix. In the case of short-range potentials, the concept of asymptotic convergence is, loosely speaking, as follows: a time-dependent normalizable scattering solution of the Schrödinger equation with interaction can be approximated, for large positive and negative times, by a wave function whose time-dependence is governed by a free Hamiltonian. It is then possible to interpret the wave function at large positive and negative times as describing outgoing or incoming free particles of various kinds; this is the interpretation needed to depict the usual experimental situation. It has long been suspected that, due to the long range of Coulomb potentials, the customary definition of asymptotic convergence does not apply when such potentials are involved. This is shown to be the case. A new definition of asymptotic convergence is proposed for the Coulomb field, and a convergence proof is given. The S-matrix resulting from this condition is shown to be correct in the case of potential scattering, and its plausibility is argued in the case of multichannel scattering. In the analysis of potential scattering, an integral scattering equation is derived which holds for either Coulomb or short-range potentials. A review is included on the following important mathematical problems arising in the time-dependent non-relativistic theory: self-adjointness of the Hamiltonian, asymptotic convergence, the definition and unitarity of the S-matrix, and asymptotic completeness of states. In the course of the review, one or two extensions of ideas found in the literature are given, relating to the second-quantized theory. (Dissertation Abstr., 24: No. 11, 1964)

**28269** ELECTRON SPIN RESONANCE OF LITHIUM AND SODIUM METAL AT VERY HIGH PRESSURES. William James Murri. Thesis, Provo, Utah, Brigham Young Univ., 1963. 65p.

The electron spin resonance of lithium metal was investigated as a function of pressure up to 60 kilobars. In addition, preliminary resonance signals were obtained from sodium metal up to a pressure of 100 kilobars. The parameters measured as a function of pressure were: g value; line width; spin relaxation time; and diffusion time. The g value of both lithium and sodium was independent of pressure in the range of the measurements. For lithium, the line width and spin relaxation were pressure independent except for a sudden change at 13 kilobars. The occurrence of a strain-induced polymorphic phase transition is given

as a possible explanation of the sudden change. The diffusion time in lithium was found to have a broad minimum at approximately 20 kilobars. Two possible explanations of this behavior of the diffusion time are suggested: the minimum may be the result of the distortion of the Fermi surface with pressure; or the minimum may be associated with a strain-induced phase transition. Preliminary studies of spin resonance of copper, aluminum, ytterbium, and cerium at ambient pressure are described. A weak signal was obtained from aluminum and an oxide of cerium. A discussion of the development of the apparatus necessary to achieve these results is also presented. (Dissertation Abstr., 24: No. 11, 1964)

**28270** THE CALCULATION OF ATOMIC WAVE FUNCTIONS. Herbert Aaron Moses. Thesis, Storrs, Conn., Univ. of Connecticut, 1963. 91p.

A method for the calculation of atomic wave functions for 26 states of the cesium atom is discussed. The approach assumes an independent particle model and each electron is thought of as partially shielding the nucleus from the others. An electron is then considered to move in a screened Coulomb potential, which is taken to approximately be the potential that is obtained from the Thomas-Fermi statistical model. The potential used contains five undetermined parameters. By a process of matching the assumed potential to the Thomas-Fermi potential the values of these parameters were obtained for 26 states of cesium. These are given along with curves showing percentage deviation from the Thomas-Fermi potential. Also given are calculated values of energies for each state along with a comparison with energies obtained from optical and x-ray data. Agreement was good. Finally, for purposes of calculation of normalization constant, fine structure, and hyperfine structure, the screening function assumed was inverted for all states and expressed as an exponential series so that integrals involved in these calculations can be easily evaluated. (Dissertation Abstr., 24: No. 11, 1964)

**28271** AN INVESTIGATION OF THE ANALYTIC PROPERTIES OF THE FIVE-POINT FUNCTION IN PERTURBATION THEORY. Richard Alexander Morrow. Thesis, Princeton, N. J., Princeton Univ., 1963. 153p.

The singularity structure of the Feynman amplitude associated with the five-point single loop diagram was investigated in two complex variables for the case of scalar mesons. In the course of the study formulas for the geometry of the Landau curves of the n-point function, in a particular pair of variables, were derived and subsequently applied to the five-point function. General values of the masses are allowed with the restriction that they be stable and the resulting singularity curves are classified on configurations determined by the masses and remaining independent kinematic invariants. The general equations for the physical region for an n-particle process are written down and solved, in two variables, for the case n = 5. A search was then carried out for possible processes that have a five-point singularity near to the physical region with the result that, apparently, none exist. (Dissertation Abstr., 24: No. 11, 1964)

**28272** PRODUCTION OF EXCITATION AND IONIZATION IN HELIUM BY SINGLE ELECTRON IMPACT. Robert M. St. John and Chun C. Lin (Univ. of Oklahoma, Norman). 12p. (CONF-531-3)

From American Physical Society, 1964 Southwestern Meeting, Tucson, Ariz., Feb. 1964.

The production of excited $He^+$ ions by single electron impact collisions with ground state helium atoms was observed by the optical method. The absolute value of the cross section for the collision process yielding the n = 4 → n = 3 transitions (4686 Å) in $He^+$ was determined for incident electron energies from 60 to 470 ev. The excitation-ionization cross section exhibited a single broad maximum at 200 ev with an onset at 75 ev. The peak value of the cross section was $4.2 \times 10^{-21}$ $cm^2$. Stepwise ionization and excitation was nowhere in evidence. The excitation-ionization function was independent of gas pressure. Light yield was proportional to the electron beam current. Comparisons were made with previous experimental results and with theoretical predictions. (auth)

## Cosmic Radiation

*Refer also to abstracts 28228, 28232, 28904, 28905, and 28906.*

**28273** (AFCRL-63-855) EXPERIMENTAL EVIDENCE OF A DIRECTIONAL EVENT DURING THE COSMIC-RAY STORM IN DECEMBER 1957. Technical Note No. 2. Oscar L. Troncoso (Uppsala Univ. Inst. of Physics). May 1963. Contract AF61(052)-614. 29p. (AD-415385)

On December 22 to 24, 1957, a significant cosmic ray increase of short duration took place in the interval between two moderate magnetic storms and during the recovery of a cosmic ray storm. Data were used from 24 cosmic ray stations distributed all over the world. The increase was observed only by stations contained within a limited region of the earth's surface. The increase, which lasted for about 14 hours, took place at about the same local time for all stations that detected it. The average direction of the arriving particles corresponded to 10 hours LT. A second peak, occurring at all stations at about 03 LT, is interpreted as a continuation of the effect generating the first increase. Characteristic features of both increases are presented together with data of solar and terrestrial activity. There is no clear correlation between the occurrence of these peaks and such activities. The modulation mechanism producing the increase is discussed. (auth)

**28274** (JPRS-25029) INVESTIGATIONS OF THE NUCLEAR COMPONENT OF COSMIC RAYS MADE ON SOVIET SATELLITES AND ROCKETS. V. L. Ginzburg, L. V. Kurnosova, L. A. Razorenov, and M. I. Fradkin. Translated from Usp. Fiz. Nauk, 82: 585-647(Apr. 1964). 101p. (OTS-64-31455)

Results of Russian satellite and rocket investigations of the nuclear component of cosmic radiation are discussed. 137 references. (R.E.U.)

**28275** DIURNAL INTENSITY VARIATIONS IN THE OUTER RADIATION ZONE AT 1000 KM. I. B. McDiarmid and J. B. Burrows (National Research Council, Ottawa). Can. J. Phys., 42: 1135-48(June 1964). (NRC-7921)

A diurnal variation was observed at 1000 km in the outer radiation zone in the average intensity of trapped electrons with energies greater than 40 kev and in the average intensity and frequency of occurrence of precipitated electrons of the same energy. The amplitude of the variation is greatest near the high-latitude boundary of the outer zone, but extends down to invariant latitudes of $\lambda = 60°$ ($L \sim 4.5$). In the latitude range $\lambda = 60°$ to 68°, the shape of the distributions of average intensity against local time is very similar for both the trapped and precipitated elec-

trons, with the daily maximum occurring around 0800 hours local time. Good statistical agreement is obtained between the frequency of occurrence of precipitation and auroral absorption at two different local times. (auth)

**28276** DISTRIBUTION OF CHARGED PARTICLES TRAPPED IN A VARYING STRONG MAGNETIC FIELD (ONE-DIMENSIONAL CASE) WITH APPLICATIONS TO TRAPPED RADIATION. Tomiya Watanabe (Univ. of British Columbia, Vancouver, Can.). Can. J. Phys., 42: 1185-94(June 1964).

The differential equation for the distribution function of charged particles trapped in a strong magnetic field is discussed for the case in which the charged particles are constrained in a tube of magnetic lines of force with a small normal cross section (the one-dimensional case). The distribution function is not defined by the six canonical variables, the variables in geometrical space and velocity space, as is done usually when referring to the Boltzmann equation. Instead, it is defined by the space coordinates of the guiding center of a representative particle together with its speed and pitch angle (i.e., five variables, in the three-dimensional case). Several problems relating to trapped radiation are discussed using the differential equation. (auth)

**28277** SEMIDIURNAL VARIATION OF COSMIC RAY NUCLEONIC INTENSITY. Ch. V. Sastry (Indian Inst. of Science, Bangalore). Current Sci. (India), 31: 499-500 (Dec. 1962).

Preliminary results of a study of the semidiurnal variation of cosmic ray nucleonic intensity are presented. The data from the Huancayo ($\lambda = 0.6°$, height 3400 m) and Climax stations ($\lambda = 48°$, 3400 m) for the period from July 1957 to March 1958 are used. When the monthly mean semidiurnal amplitude and phase were calculated by harmonic analysis, it was found that both the semidiurnal amplitude and phase are variable in character. The changes in amplitude are more pronounced at Climax than at Huancayo. Unlike the diurnal variation, the variations in amplitude are not in the same sense at the two stations. The amplitude at Huancayo does not show any dependence on $K_p$ (geomagnetic planetary index). However, there is better correlation between the amplitude at Climax and $K_p$. It was previously shown that the diurnal amplitude increases on days of low mean intensity, but the semidiurnal amplitude observed does not show any such relation at either latitude. The times of the maxima at the two stations are better correlated, but they do not show any apparent dependence on $K_p$, sunspot number, or daily mean intensity. Previous studies of the semidiurnal variation of meson intensity showed that the amplitude is reduced on high $K_p$ value days and that times of maxima of semidiurnal variation are significantly different at different latitudes and changes in the times are not correlated at different stations. However, for the nucleonic intensity there seemed to be a positive correlation between the amplitudes and $K_p$ at high latitudes. The average amplitude and time of maximum for Huancayo and for Climax are $0.08 \pm 0.01\%$ and 4 hr, 4 min; $0.10 \pm 0.005\%$ and 3 hr, 36 min, respectively. From the average amplitude and phase, it appears that there is no latitude dependence. (BBB)

**28278** THE VAN ALLEN RADIATION ZONES. I. THE THEORY OF TRAPPING AND THE INNER ZONE. W. G. V. Rosser (Univ. of Exeter, Eng.). Contemp. Phys., 5: 198-211(Feb. 1964).

An account is given of the theory of the trapping of charged particles by the earth's magnetic field. Trapping of particles following high altitude nuclear explosions and the nature and intensity of particles trapped in the inner radiation zone are described. (auth)

**28279** ON THE STATISTICS OF THE SLOWLY VARIABLE COMPONENT OF SOLAR RADIO RADIATION IN THE PRESENT SPOT CYCLE. G. Wallis, W. Krueger, and A. Krueger. Monatsber. Deut. Akad. Wiss. Berlin, 5: 684-8(1963). (In German)

A statistical analysis was made of the correlation between variations in the solar radio radiation and the number of sun spots. Since radio radiation can be related to uv and x-ray emission from the sun, it was concluded that this analysis can be used in treatment of solar-terrestrial relations. (M.C.G.)

**28280** MAGNETIC QUIET DAY RELATIONSHIPS. Gerald F. Rourke (Avco Corp., Wilmington, Mass.). Nature, 202: 891(May 30, 1964).

The K indexes from thirteen Antarctic magnetic observatories were used to rank each day of the month according to the degree of activity. Seasonal changes are discussed. (R.E.U.)

**28281** EXCITATION OF LUNAR LUMINESCENCE BY SOLAR PROTONS. S. P. S. Anand, L. Oster, and S. Sofia (Yale Univ., New Haven). Nature, 202: 1097-8(June 13, 1964).

The possibility that the red glow observed November 1, 1963, on the moon was caused by bombardment of the region with solar protons is discussed. (M.C.G.)

**28282** SOFT GAMMA BACKGROUND RADIATION AT THE EARTH'S SURFACE AND AT AIRCRAFT ALTITUDES. R. J. Hanson (Grinnell Coll., Iowa) and D. Marker. Nuovo Cimento (10), 32: 793-815(May 16, 1964).

The soft $\gamma$ radiation which produces rather high background rates in unshielded scintillation counters was studied at the earth's surface and at aircraft altitudes. It is concluded that near the surface of the earth the radiation is primarily from the earth and building materials. At high aircraft altitudes it is primarily due to degraded cosmic radiation and at lower altitudes it is due to air radioactivity and cosmic radiation. Energy spectra at the earth's surface and at aircraft altitudes are presented. Most of the radiation below 500 kev is included in the region from 40 kev to 200 kev with a prominent peak between 50 kev and 85 kev. Since most of the photons emitted from the various sources undergo several Compton interactions before detection, the location of the peak is nearly independent of the energy of the source. The peak location depends primarily on the photoelectric and Compton cross-sections of the medium (air, earth, or building materials) surrounding the detector. Theoretical calculations of the shape of the spectrum are given and are in good agreement with the experimental data. A calculation of expected underground intensity near the earth's surface based on known average concentrations of radioactive materials in the earth's crust is consistent with experimental results. (auth)

**28283** COSMIC-RAY MUON POLARIZATION STUDIES OF THE $K/\pi$ RATIO. J. L. Osborne (Univ. of Durham, Eng.). Nuovo Cimento (10), 32: 816-26(May 16, 1964).

A critical analysis is made of the results of various workers on the polarization of cosmic-ray muons at sea level, and the data are combined to give the best estimate of the polarization as a function of momentum. Under the assumption that the sea level muons are derived from kaons and pions, the ratio of the frequency of production of kaons

to pions is derived as a function of energy of the initiating nucleons. Equal production of charged and neutral kaons is assumed, and all kaon decay modes are considered. The result is consistent with a $K/\pi$ ratio, the ratio of charged and neutral kaons to charged and neutral pions of a given energy at production, of (40 ± 20)% for kaon and pion energies from 4 to 18 Bev, corresponding to primary energies in the range (50 to 300) Bev. (auth)

**28284** THE DETAILED STRUCTURE OF AIR SHOWER CORES. A. D. Bray, (Univ. of Sydney), D. F. Crawford, D. L. Jauncey, C. B. A. McCusker, P. C. Poole, M. H. Rathgeber, J. Ulrichs, R. H. Wand, M. M. Winn, and A. Ueda. Nuovo Cimento (10), 32: 827-46(May 16, 1964).

An array of 64 large plastic scintillators, 5 Wilson cloud chambers and about 500 G-M counters was used to study the electronic structure of air-shower cores. On average the single cores follow the Nishimura-Kamata distribution with the age parameter slightly greater than unity. Multiple-cored and flat-topped showers can be simulated by the summation of a number of spatially separated single cores. It is shown that the multiply cored showers can not be due to cascades produced by the neutral pions from a single interaction, but that the core structure is due to the nature of the primary particle. The central density of single-cored showers is considerably higher than the central density of multiply cored showers of the same size. Up to $N = 10^6$ the ratio of singly cored showers to others is the same as the ratio of the numbers of protons to other primaries (of the same total energy) at lower energies. Above $N = 10^6$ there is a great increase in the ratio of multiply cored to single-cored showers. This suggests that there is a change in the composition of cosmic radiation at about $3 \cdot 10^{15}$ ev. (auth)

**28285** THE DIRECT PRODUCTION OF ELECTRON PAIRS BY HIGH-ENERGY MUONS UNDERGROUND (148 m w.e.). N. Chaudhuri and M. S. Sinha (Regional Engineering Coll., Durgapur, [India)]. Nuovo Cimento (10), 32: 853-62(May 16, 1964).

Direct production of electron pairs in thin iron targets by muons of mean energy 32.6 Bev was studied with a multiplate cloud chamber at a depth of 148 m w.e. underground. Showers of two or more electrons associated with each outgoing muon from the targets were selected and their energy distribution determined for the target thicknesses 0.54 and 1.6 cm. The cross sections for direct pair production of electrons as obtained from events produced in both thick and thin targets agree satisfactorily with those given by the Murota-Ueda-Tanaka theory in the ranges of energy-transfer (35 to 100), (100 to 500), and (500 to 1000) Mev. (auth)

**28286** A POSSIBLE INTERPRETATION OF ULTRA-HIGH-ENERGY EXPERIMENTAL DATA. A. Krzywicki (CERN, Geneva). Nuovo Cimento (10), 32: 1067-84(May 16, 1964).

It is argued that experimental results at cosmic-ray energies do not indicate that existence of any strong correlation between secondaries. Most of the observed features of jets may be considered as consequences of two facts: i) transverse momenta of secondaries are small, ii) average inelasticity is small. These two facts may be easily understood, for instance on the basis of the multiperipheral model. The origin of the two-center jets was examined previously. The properties of the asymmetric jets are discussed. It is shown that the notion of a fire ball is not necessary to explain the data. A statistical model taking i) and ii) as basic conditions is constructed. (auth)

**28287** INVESTIGATION OF COSMIC RAYS. P. V. Vakulov, S. N. Vernov, E. B. Gorshakov, Yu. I. Logachev, A. N. Charakhchyan, T. N. Charakhchyan, and A. E. Chudakov (Academy of Sciences, Moscow). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 26-59(1964).

Cosmic ray study by means of balloon soundings in 1958–62 is reported. It was discovered that when the earth was beyond the corpuscular flux generated by a solar flare, the solar proton spectrum, if expressed as $N(>E) \sim E^{-\gamma}$, had the $\gamma$ index ~2. When the earth was within the corpuscular flux and a magnetic storm and the Forbush decrease of cosmic ray intensity were observed on the earth, the $\gamma$ index ~5. The effect of softening, during a magnetic storm, of energetic spectrum of the protons arriving from the sun is caused by new protons being trapped in the magnetic fields of the corpuscular fluxes and brought to the earth. There are also given data on the time-dependence of solar proton intensity for various flares and on the basis of this dependence coefficients of proton diffusion in interplanetary space are defined. The long monitoring of cosmic ray intensity in the stratosphere allowed to detect the 11-year intensity changes. These changes are in good correlation with solar activity. Cosmic ray intensity near the solar minimum is almost twice as much as that during the solar maximum. The results obtained during the flights of Mars-1 and Luna-4 automatic space station are discussed. During the Mars-1 flight the cosmic ray intensity was rated when the station was remote from the sun by 1.24 astronomic unit. The intensity of cosmic radiation at these distances remained constant within 3 per cent of accuracy. A comparison of the intensity of cosmic radiation recorded by the same instrumentation in 1959, during the flights of space rockets, and in 1963, during the flights of Mars-1 and Luna-4 automatic space stations, shows that the flux of initial cosmic radiation in 1963 was almost twice as much as the flux in 1959. During the Luna-4 flight there were detected slow and smooth changes of cosmic radiation intensity with up to 5 per cent amplitude and typical time of about 5 to 7 days. A comparison with the stratospheric changes of cosmic ray intensity showed that these variations were caused by the protons of 1 to 2 Bev energy. It is stressed that the solar wind was propagating from the sun to the earth for 5 to 7 days too and hence the magnetic conditions in the space region near the earth may change with the same period and cause smooth fluctuations of cosmic ray intensity. There are also discussed the results of the rating of the intensity of the radiation belts of the earth. (auth)

**28288** LIFETIME AND TIME HISTORIES OF TRAPPED RADIATION BELT PARTICLES. Wilmot N. Hess (Goddard Space Flight Center, Greenbelt, Md.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 60-76(1964).

Recent advances in understanding the lifetimes of trapped radiation belt particles are reviewed. The problem of particle lifetimes was one of the most important and perplexing in radiation belt work for several years. As a result of the past year's work, a good deal more is known about the natural Van Allen radiation belt and the characteristics of the artificial belts produced by high altitude nuclear explosions. This increased knowledge is based on both observations and calculations of the artificial belts and Van Allen belt. This better understanding of particle lifetimes is a substantial step forward in forming an overall picture of the radiation belt in that one now has a basis for selecting source and loss processes more realistically and therefore making better models of the belt. Electron lifetimes based on data collected from the high altitude ex-

plosions of the US and USSR and proton lifetimes in the Van Allen belt are discussed. (auth)

**28289** HIGH LATITUDE PARTICLE FLUX MEASUREMENTS FROM THE SATELLITE 1962 BETA ALPHA (ALOUETTE). I. B. McDiarmid, J. R. Burrows, D. C. Rose, and Margaret D. Wilson (National Research Council, Ottawa). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 606-20(1964).

The particle detectors in the Alouette satellite were used to obtain time averaged intensity distributions for the particles in the outer radiation zone at an altitude of 1000 km. Average intensities of protons in the energy range 1 to 7 Mev and electrons with energies greater than 40 and 250 kev and 3.9 Mev were obtained as a function of the invariant latitude, the particle pitch angle and magnetic activity as determined by the $K_p$ index. (auth)

**28290** SOME NOTES ON THE OUTERMOST BELT OF CHARGED PARTICLES. (Supplement of the Report "Measurements Made in the Earth's Magnetosphere by Means of Charged Particle Traps Aboard the Mars 1 Probe"). K. I. Gringauz (Academy of Sciences, Moscow). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 627-9 (1964).

Low-energy electron fluxes in the boundary region of the magnetosphere are discussed. (C.E.S.)

**28291** WHAT DETERMINES THE LIFETIME OF TRAPPED PROTONS? S. F. Singer (U. S. Weather Bureau, Washington, D. C.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 681-9(1964).

Observations on high-energy trapped protons confirm the hypothesis that lifetime is controlled by atmospheric density only, coupled with a breakdown of the magnetic moment invariant which proceeds according to a simple theoretical model. As a consequence, long lifetimes are possible for protons trapped close to the earth's surface; they are of the order of several hundred years, indicating a high degree of stability of the orbits. These conclusions lend further strong support to the neutron albedo theory for the origin of trapped protons. Suggestions are made for using the radiation belt to detect a hypothetical belt of trapped dust particles. (auth)

**28292** STRUCTURE OF THE EARTH'S RADIATION BELTS AT AN ALTITUDE OF 320 KILOMETRES. S. N. Vernov, I. A. Savenko, P. I. Shavrin, and L. V. Tverskaya (Moscow State Univ.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 908-13(1964).

Using data from the 2nd Soviet spaceship-satellite, the intensity distribution in the radiation belts at an altitude of 320 km was studied. The dependence of intensity on longitude, for various values of the drift shell parameter L was obtained. A variation of intensity as a function of longitude was discovered along the lines of equal B (B denotes magnetic field intensity). The connection of intensity with the structure of the real geomagnetic field was traced. (auth)

**28293** COSMIC RADIO INTENSITIES AT 1.225 AND 2.0 Mc MEASURED UP TO AN ALTITUDE OF 1700 km. D. Walsh, F. T. Haddock, and H. F. Schulte (Univ. of Michigan, Ann Arbor). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 935-59(1964).

A description is given of a rocket flight to 1700 km altitude for the purpose of measuring cosmic noise intensities at 0.75, 1.225, and 2.0 Mc. Above the peak of the ionosphere no signals originating on the bottomside were detected. Modulation of the radiometer outputs due to vehicle spin was observed throughout the trajectory. At the higher parts this was unrelated to the ionosphere and was presumably due to non-uniformity of sky brightness. At lower altitudes a series of ionospheric effects was observed and is discussed in relation to impedance behavior of an antenna in a magnetoionic plasma. The disappearance of the extraordinary wave at the level $X = 1 - Y$ was detected and clearly identified by the sharp drop in signal and the enhanced angle-dependence of the radiation resistance. Previously unreported regions in the ionosphere of high noise levels were detected, and the conditions for their occurrence in relation to propagation behavior in the ionosphere is delineated. The validity of semi-theoretical corrections of cosmic noise measurements for the plasma influence on the antenna is demonstrated. Cosmic noise intensities at 1.225 and 2.0 Mc of $1.0 \times 10^{-20}$ and $2.0 \times 10^{-20}$ w $m^{-2}$ $c^{-1}$ $sr^{-1}$, respectively, were obtained. Combined with selected higher frequency measurements this shows a sharp break in the spectrum near 2.0 Mc. The corresponding cosmic brightness temperatures are $2.1 \times 10^7$ and $1.7 \times 10^7$ °K, at 1.225 and 2.0 Mc, respectively. (auth)

**28294** SPECTRUM OF HEAVY NUCLEI IN THE PRIMARY COSMIC RADIATION. M. A. Pomerantz (Franklin Inst., Swarthmore, Penna.), S. P. Duggal, and L. Witten. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 972-88 (1964).

The magnetic rigidity spectrum of heavy nuclei (atomic number $Z \geq 6$) in the primary cosmic radiation, characterizing solar maximum conditions, was determined from an analysis of data obtained with a pulse ionization chamber operating aboard Explorer VII. If the relation between flux and rigidity is expressed as a power law, $N(>R) = KR^{-\gamma}$, three different exponents are required to represent the data. Their values are: $1 < R < 3.5$, $\gamma = 0.20 \pm 0.06$; $3.5 < R < 8.5$, $\gamma = 0.80 \pm 0.06$; $8.5 < R < 15.5$, $\gamma = 1.25 \pm 0.19$. The value of $\gamma$ for the single straight line that best fits the data above 4 Gv is $0.90 \pm 0.04$. This is appreciably lower than the corresponding value, $\gamma = 1.5$, determined previously by other techniques at solar minimum. The results clearly indicate that lower rigidity particles are removed more efficaciously by the solar cycle modulation process. The data over the entire range covered by these observations, 1.0–15.5 Gv, follow the exponential relation $N(>R) = K \exp[-R/R_0]$ with $R_0 = 7.94 \pm 0.25$ for the so-called quiet period comprising seventy-six days characterized by the absence of cosmic ray storm effects, as indicated by the records of widely dispersed neutron monitors. From measurements during a Forbush-type decrease, the rigidity-dependence of the modulation was determined, and compared with the spectrum of variation deduced from data recorded by neutron monitors. The differential modulation relation, $\delta J(R)/J(R) = KR^{-\gamma}$, with $\gamma = 1$, yielded reasonable agreement with the observations in both cases, indicating that the modulation of the heavy nuclei was the same as that of the proton component. This is consistent with the expectation that magnetic rigidity is probably the fundamental parameter in the modulation process. (auth)

**28295** AN ATTENUATION KERNEL FOR THE BAILEY MODEL EVENT. J. W. Haffner (North American Aviation, Inc., Downey, Calif.). Trans. Am. Nucl. Soc., 7: 16(June 1964).

**28296** EFFECTIVE MARS MISSION RADIATION DOSES. J. W. Haffner and E. R. Beever (North American Aviation, Downey, Calif.). Trans. Am. Nucl. Soc., 7: 20-1(June 1964).

**28297** A STUDY OF "YOUNG" HIGH ENERGY ELECTRON-PHOTON AIR SHOWERS. Kh. P. Babayan,

N. G. Boyadzhyan, N. L. Grigorov, E. A. Mamidzhanyan, Ch. A. Tretyakova, and V. Ya. Shestoperov (Moscow State Univ. and Inst. of Physics, Erevan, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1525-39(May 1964). (In Russian)

Characteristics of the electron-photon component of young air showers with energies $E \geq 1.7 \times 10^{12}$ ev are investigated. The energy spectra of showers with various lateral electron-photon energy flux distributions are obtained. The absorption range of nuclear particles with energies $E \geq 2 \times 10^{12}$ ev in the lower part of the atmosphere is found to be $L_p = 109 \pm 8$ g/cm$^2$. Some possible mechanisms of production of young atmospheric showers are considered. (auth)

**28298** THE ENERGY SPECTRUM AND TOTAL NUMBER OF X-RAY PHOTONS IN EXTENSIVE COSMIC RAY AIR SHOWERS. G. A. Bazilevskaya, A. F. Krasotkin, and A. N. Charakhchyan (Lebedev Inst. of Physics, Moscow). Zh. Eksperim. i Teor. Fiz., 46: 1553-60(May 1964). (In Russian)

Results of a study of low energy (x ray) photons in extensive air showers are presented. The energy spectrum measured and the total number of photons in the showers are in agreement with the results of calculations for an equilibrium spectrum of photons produced in electron-photon cascades. (auth)

**28299** DETERMINATION OF THE TOTAL NUMBER OF NUCLEAR-ACTIVE PARTICLES IN EXTENSIVE AIR SHOWERS CONTAINING FROM $3.10^3$ TO $10^7$ PARTICLES. T. V. Danilova, E. V. Denisov, and S. I. Nikolskii (Lebedev Inst. of Physics, Moscow). Zh. Eksperim. i Teor. Fiz., 46: 1561-77(May 1964). (In Russian)

The dependence of the number of nuclear particles, $N_{n,a}$, on the total number of shower particles, N, was measured for $N = 3 \times 10^3 - 10^7$. Showers with a given number of particles and an axis that passed near the center of the experimental arrangement were selected by combining coincidence and anticoincidence counters of a given area. The nuclear particles were recorded by five neutron detectors which differed in effective area, thickness of lead absorber, and distance from center of the arrangement. According to the data the integral number spectrum (at 3330 meters above sea level) can be expressed by the formulas $S(>N) = (1.1 \pm 0.1) \times 10^{-2} (N/3.5 \times 10^5)^{-1.23}$ hour$^{-1} \cdot$ m$^{-2}$ for $N < 3.5 \times 10^5$, $S(>N) = (1.1 \pm 0.1) \times 10^{-2} (N/3.5 \times 10^5)^{-1.5}$ hour$^{-1}$ . m$^{-2}$ for $N > 3.5 \times 10^5$. It is possible that the shower spectrum exponent is reduced at small values of N (but no more than by 0.1) due to the effect of the change in the shower particle lateral distribution function near the shower axis. The dependence of the number of nuclear particles on the total number of shower particles can be represented by a power law with an exponent $0.72 \pm 0.06$. The absolute flux of nuclear particles is in satisfactory agreement with the results of Cocconi and Marsden obtained with the same threshold value and leads a reasonable spectrum for nuclear particles in showers ($F(>E) \sim E^{-0.45 \pm 0.15}$) for energies between $2 \times 10^8$ and $3 \times 10^9$ ev when compared with the results of high energy measurements. Energy estimations show that the energy contribution of nuclear particles is different for large and small showers. Comparison of the results of various experiments on investigation of the dependence of the number of nuclear particles on the total number of shower particles shows that a better approximation than the single formula $N_{n-a} \sim N^{\beta}$ ($\beta$ is a constant) for energies in the range $3 \times 10^3 < N < 2 \times 10^6$ is the set of formulas $N_{n-a} \sim N^{0.79}$ for $N < 5 \times 10^4$, $N_{n-a} \sim N^{0.4}$ for $5 \times 10^4 < N < 2 \times 10^5$ and $N_{n-a} \sim N^{0.96}$ for $2 \times 10^5 < N < 2 \times 10^6$. (auth)

**28300** CALCULATION OF THE FLUCTUATIONS OF THE TOTAL NUMBER OF $\mu$-MESONS IN EXTENSIVE AIR SHOWERS. L. G. Dedenko (Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 46: 1859-64(May 1964). (In Russian)

The distribution of number of $\mu$ mesons in a shower with a given number of particles and the distribution of number of particles in a shower with a given number of $\mu$ mesons as functions of the primary radiation of complex composition at sea level and at mountain heights (640 g/cm$^2$) are calculated on the assumption that there is a unique relation between the total number of high energy $\mu$ mesons and energy of the primary particle of the extensive air shower. (auth)

**28301** OBSERVATIONS OF SOLAR AND GALACTIC COSMIC RAYS WITH SATELLITE EXPLORER VII, OCTOBER 1959 TO FEBRUARY 1961. Wei-Ching Lin. Thesis, Iowa City, Iowa, Iowa State Univ., 1963. 179p.

During the sixteen month period October 13, 1959 to February 17, 1961, twenty-one distinct solar cosmic ray events were observed with Explorer VII (earth satellite 1959 Iota) at high latitudes over North America and Australia in the altitude range 550 to 1100 km. It was found that the time decay of intensity from its peak value can be represented by $t^{-s}$, where t is measured from the onset of the apparently responsible solar flare and the value of the exponent s for several cases is as follows: 2.1 for April 1-2; 3.5 for April 28-29; 1.2 for May 4-5; 2.8 for May 13-14; 2.9 for September 3-8; 2 for November 12-15; and 3.4 for November 15-19, 1960. The latitude dependence of solar cosmic ray intensity at various longitudes and for both Northern and Southern Hemispheres was studied for eight of the major events, which yielded sufficient data for definitive analysis. Such bodies of data exhibit a chaotic pattern when plotted against traditional geomagnetic cutoffs. $L_{min}$, the minimum value attained by 30 Mev protons is strongly and systematically depressed during the main phase of geomagnetic storms. The correlation coefficient between $L_{min}$ and U is $-0.88$ and between $L_{min}$ and H is $+0.86$, where U is the Kertz parameter, which gives a measure of the equatorial ring current and H is the horizontal component of the geomagnetic field (at Tucson). The observed $L_{min}$ of about 5.2 during quiet periods implies the existence of a quiescent ring current. During magnetically disturbed periods, the observed $L_{min}$ of about 3.5 does not seem likely to be explained by the effect of a ring current alone. Using a shielded Geiger tube in the Explorer VII satellite, a comprehensive geographic survey of the intensity of charged particles was conducted in the latitude range $\pm 50.5°$, in the altitude range 550 to 1100 km, and over the sixteen month time period October 13, 1959 to February 17, 1961. It was found possible to identify and eliminate contributions by geomagnetically trapped particles and thus to obtain the absolute intensity of primary galactic cosmic rays and their charged particle secondaries (albedo) produced in the atmosphere. Specific results are as follows: Comparison between observations by Explorer VII and Air Force Satellite Flight No. 31 confirmed the Explorer VII value of L = 2.9 as representing the edges of both northern and southern polar plateaus and shows it to be applicable to the complete range of longitudes in both hemispheres. Thus, a further example of the validity of L as a useful latitude parameter is exhibited; and it appears that the position of the edges of the plateaus in September 1961 did not differ significantly from the average position during the period October 1959 to February 1961. It is shown empirically that Quenby-Wenk cutoffs and L derived cutoffs are equally good for the single-parameter representation of cosmic ray intensity distribu-

tions. Study of the relationship of the observations with Explorer VII to those with high latitude riometers shows that solar protons with E > 30 Mev play a minor role in PCA phenomena. A spectral hardness parameter $H \equiv J_0 (E > 30 \text{ Mev})/[A(db)]^2$ is introduced. It is seen that the values of H are quite different from event to event and that during the time decay of a given event the dominant tendency is for the value of H to decrease or, in limiting cases, to remain approximately constant. A brief discussion of the interplanetary diffusion model for the time decay of solar proton intensities is presented. The observed decay of solar proton intensities seems to be reasonably well explained by a diffusion model with a finite absorbing boundary except for the very early period of the decay phase. A comparative listing of solar cosmic ray events as detected by various techniques is given. (Dissertation Abstr., 24: No. 11, 1964)

## Criticality Studies

**28302** PULSED-NEUTRON SOURCE MEASUREMENTS AND ANALYSES OF RANDOM NOISE IN SMALL MULTIPLYING SYSTEMS. R. W. Albrecht, S. R. Bierman, and K. L. Garlid (General Electric Co., Richland, Wash.). Trans. Am. Nucl. Soc., 7: 47-8(June 1964).

**28303** PROMPT-NEUTRON LIFETIME IN ENRICHED-URANIUM METAL CYLINDERS. J. T. Mihalczo (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 48-9(June 1964).

## Direct Energy Conversion

*Refer also to abstract 29015.*

**28304** (APL-TDR-64-2) ADDITIVE CONVERTER STUDIES. S. S. Kitrilakis and J. H. Weinstein (Thermo Electron Engineering Corp., Waltham, Mass.). Jan. 1964. Contract AF33(657)-10130. 57p.

A program aimed at improving the performance of thermionic converters by the use of cesium halide additives is reported. Results show that such improvement is achieved and is a result of the reduction of collector work function at each operating condition. The reduction in work function is achieved by a shift in the ratio of collector-to-cesium reservoir temperature ratio at which the minimum collector work function is obtained, thus allowing the converter to be operated closer to the condition of minimum collector work function than is useful in the cesium-only case. Corrosion and metallurgical examinations show no evidence of chemical attack, attributable to the additives, upon converter components. (auth)

**28305** (APL-TDR-64-63) THERMIONIC CONVERTER SURFACE CONDITIONS. V. C. Wilson and J. Lawrence (General Electric Co. Research Lab., Schenectady, N. Y.). May 1964. Contract AF33(657)-10132. 70p.

The effect of various emitter materials and surface conditions in a plane parallel cesium vapor thermionic converter was studied. Four thermionic converters were fabricated and tested. The first had a niobium carbide emitter and a molybdenum collector. For this converter, the maximum output power was considerably lower than that from a previously tested similar converter with a tungsten emitter and a molybdenum collector. The second converter had an oxygen-treated tantalum emitter and a molybdenum collector. This converter had the same maximum output as reported for a clean tantalum emitter-molybdenum collector converter except that the converter with the oxygen-treated tantalum emitter operated at half the cesium pressure necessary for the converter with the clean tantalum emitter. This suggests that the oxygen-treated tantalum surface adsorbs cesium more strongly than does the clean tantalum surface. Experience gained testing the first two converters showed the desirability of modifying the converter design. The last two converters were improved in several details, but primarily each had an insulated guard ring surrounding the collector and provisions were provided so that during operation the collector and guard ring potentials and temperatures could be kept identical. Special care was taken to procure the purest materials and to clean and outgas all the parts of these converters. One of the new design converters had a tungsten emitter and nickel collector. The other had a rhenium emitter and nickel collector. Both had 0.005-inch separation between the emitter and collector. The W–Ni converter at $T_E$ = 2235°K developed an output power density at the electrodes of over 40 watts/cm$^2$ (68 amp/cm$^2$ at 0.6 volt). At this high-current density the electron cooling is large, the input power is large, and a calculated useful efficiency of 12% was obtained. A peak calculated efficiency of 18.7% occurred at 17 amp/cm$^2$ and 1.06 volts or at a power density of 18.1 watts/cm$^2$ delivered at the output terminals. The Re–Ni converter was not driven to as high emitter temperatures or output currents; however, in general, its output voltage was higher than the W–Ni converter under similar conditions. At 2150°K the Re–Ni converter had an output power at 15 amp/cm$^2$ of 16.8 watts/cm$^2$ and a calculated efficiency of 19.8%. (auth)

**28306** (MND-2933-2) RESEARCH AND DEVELOPMENT FOR BARIUM VAPOR-FILLED THERMIONIC ENERGY CONVERSION TECHNOLOGY. Summary Report. A. J. Kennedy (Martin-Marietta Corp. Aerospace Div., Baltimore). May 1964. Contract AT(30-1)-2933. 140p.

Experimental data are given for plasma thermionic energy converters in which barium, rather than cesium, is used as the vapor material. Barium adsorption on refractory metal emitters, in the temperature range of 1800–2200°K is such that current densities of 1 to 10 amp/cm$^2$ are obtained at vapor pressures of less than 0.1 mm Hg. Consequently, power losses due to collision in the interelectrode gap are quite small; and performance shows little dependence on interelectrode spacings, even for spacing as large as 0.020 to 0.050 in. Performance of the barium vapor-filled converter is also marked by an ability to use a high collector temperature; output power densities in the range of watt/cm$^2$ maximize at collector temperatures in excess of 1200°K. (auth)

**28307** SPACE-CHARGE EQUATIONS WITH NEGATIVE ION EMISSION IN COLLISIONLESS DIODES. C. H. Skeen (Atomics International, Canoga Park, Calif.). J. Appl. Phys., 35: 2262-3(July 1964).

The influence of negative-ion emission in plane parallel collisionless thermionic diodes on space-charge equations that were modified for positive-ion emission is discussed. (R.E.U.)

**28308** MAGNETOPLASMADYNAMIC GENERATION OF ELECTRICITY. A MAJOR TECHNICAL ADVANCE BY I.R.D. Metallurgia, 69: 216-17(May 1964).

The extraction of electricity from a closed cycle magnetoplasmadynamic (MPD) generator in which the only moving part is a high-temperature gas is described. To produce electricity the gas is forced at a high velocity through a magnetic field. This is the first MPD generator

operating on the closed cycle principle (in which the working gas is continuously circulated) to produce significant output power. The closed cycle system in which heat would be provided by a nuclear reactor, operates under very pure conditions, so that temperature requirements are low. The system described operates with a mixture of pure He and Cs. (P.C.H.)

**28309** USE OF DENSE SILICON CARBIDE AS A BARRIER IN THERMIONIC DIODES TO PREVENT OXIDATION AND HYDROGEN PERMEATION. W. R. Clendinning (Texas Instruments, Dallas). Trans. Am. Nucl. Soc., 7: 103(June 1964).

**28310** FISSION-ELECTRIC CELL CAPSULE EXPERIMENTS. W. F. Krieve and C. J. Heindl (California Inst. of Tech., Pasadena). Trans. Am. Nucl. Soc., 7: 103-4(June 1964).

**28311** NUCLEAR THERMIONIC LUNAR-BASE POWER SUPPLY. W. J. Levedahl, E. A. Scicchitano, and F. A. Schumann (Martin Co., Baltimore). Trans. Am. Nucl. Soc., 7: 131(June 1964).

**28312** CONCEPTS FOR DIRECT CONVERSION OF STORED NUCLEAR ENERGY TO LASER BEAM POWER. Lloyd O. Herwig (United Aircraft Research Lab., Hartford, Conn.). Trans. Am. Nucl. Soc., 7: 131-2(June 1964).

**28313** CESIUM ION PRODUCTION IN A STRONG ION ACCELERATING FIELD. W. B. Nottingham (Massachusetts Inst. of Tech., Cambridge). 24p. (CONF-538-1)

From 23rd Annual Conference on Physical Electronics, Cambridge, Mass., Mar. 1963.

The yield of ions produced at the surface of a heated single crystal of tungsten in a thermionic diode was studied. The cesium condensation temperature was maintained at 470°K, and the surface temperature was varied from 1350 to 1590°K. The spacing of the diode was varied from 8 to 350 microns. The surface area was 1.75 $cm^2$. The ion yield was observed to follow the Schottky mirror-image theory with a good agreement between the observed slope of the Schottky line and the one computed from theory for the very shortest spacing. At larger spacings the slope of the line was much too great to correspond to the true spacing; therefore, the observed effects are attributed to formation of a plasma near the collector. At very low temperatures the observed currents were many times larger than would have been predicted by the Langmuir-Saha equation, but were in excellent agreement with the random current density that would be anticipated in an isothermal diode operating at the emitter temperature and with a cesium density equal to that used in the experiment. In the high-temperature range, ion space-charge effects were strong, and yet the zero field ion emission observed was uniformly a factor of approximately 3.7 times greater than that expected from the Langmuir-Saha theory of surface ionization. (auth)

**28314** NONPROPULSIVE POWER SUPPLIES FOR MANNED SPACE SYSTEMS. W. E. Crane (Martin Co., Baltimore). New York, Society of Automotive Engineers, Inc., and New York, American Society of Mechanical Engineers, 1964, Paper No. 867A, 9p. $1.00. (CONF-505-8)

From Society of Automotive Engineers Air Transport and Space Meeting, New York, Apr. 1964.

The significant factors in the selection of a nonpropulsive power system are indicated; and the capabilities, configurations, merits, status, and uses of solar energy systems, energy storage systems, fueled power supplies, fuel cells, chemical dynamic systems, and nuclear systems are summarized. (D.C.W.)

**28315** CURRENT STATUS AND FUTURE POTENTIAL OF THERMOELECTRIC POWER GENERATION. Melvin Barmat (General Instrument Corp., Newark, N. J.). 13p. (CONF-430-3)

From Institute of Electrical and Electronics Engineers Winter Power Meeting, New York, Feb. 1964.

The status of thermoelectric power generation is briefly reviewed from the viewpoints of theory, measurements, materials, and devices. Future uses and developments are also indicated. (D.C.W.)

**28316** THERMIONIC POWER SUPPLY. Richard C. Noyes, Bernard L. Hoffman, and Melvyn Lane Henkin (to North American Aviation Inc.). U. S. Patent 3,137,798. June 16, 1964. Filed Nov. 22, 1961.

A portable thermionic power supply is designed which is powered by conventional fuels. The supply features an integral fuel supply, an air and fuel preheating system, and automatic control of the output voltage. (D.L.C.)

**28317** THERMIONIC POWER SUPPLY. John Joseph O'Connor (to General Electric Co.). U. S. Patent 3,137,799. June 16, 1964. Filed Apr. 30, 1962.

A short-life thermionic power supply is described which has an improved power-to-weight ratio, long storage life, and improved reliability. In the power supply, a solid propellant cartridge and a thermionic energy converter of annular design are assembled as an integral unit. The hot gases produced by ignition of the propellant are made to flow through a passage in the converter to generate an electrical output therefrom. The anode and reservoir for ionized gas are placed in thermal contact with materials having specific melting points and latent heats of fusion, in order to be maintained at constant temperatures during operation of the power supply. (D.L.C.)

## Elementary Particles and Radiations

*Refer also to abstracts 28248, 28449, and 28684.*

**28318** (AD-417235) SCATTERING BY PERFECTLY CONDUCTING ARBITRARILY SHAPED CYLINDERS. Robert P. Banaugh (Northrop Corp., Newbury Park, Calif.). Aug. 26, 1963. 15p. (TP-68)

The problem of the determination of the scattered field from a perfectly conducting cylinder of arbitrary cross-sectional shape is formulated in terms of an integral equation, which is solved by a finite difference technique. Results are presented for a cross-section that is not a convex domain, and the efficacy of the numerical method of solution is compared with results computed from eigenfunction expansions. (auth)

**28319** (DESY-64/5) PHOTOERZEUGUNG VON π-MESONEN. I. TEIL. (Photo Production of π Mesons. Part I). P. Stichel (Germany. Physikalisches Staatsinstitut, Hamburg). Apr. 1964. 124p.

The first part of a lecture course on "Photoproduction of π-Mesons," given winter 1963/64 at the University of Hamburg is given. Photoproduction of pions in the resonance region ($E_\gamma$ < Bev) is considered. The main points of view of the theory and some important experimental facts are presented. A detailed discussion of resonance phenomena in the presence of inelastic channels is given in connection with the 2nd resonance. (auth)

**28320** (EFINS-63-3) THE RESTRICTIONS ON THE ASYMPTOTIC PARAMETERS REQUIRED BY THE UNITARITY CONDITION. Tetsuo Sawada (Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies and Chicago. Univ.). Jan. 1963. Contract AT(11-1)-264. 29p.

Making the analytic continuation of the unitarity condition with respect to cos $\theta$, relations are derived which connect the asymptotic parameters of large $|\cos\theta|$ and the spectral function of the crossed channel. Using these relations, the threshold behavior of these parameters is examined. Assuming the asymptotic power behavior, it is found that there are only a few possibilities for the combination of the asymptotic power series that are allowed by the unitarity condition in the vicinity of the threshold. One of these is the same as the asymptotic form of the Legendre function. Sum rules that relate the total cross section and the asymptotic parameters are derived. (auth)

**28321** (INSJ-70) CALCULATION OF THE RANGE FLUCTUATION OF HIGH-ENERGY $\mu$ MESONS. Jun Nishimura (Tokyo Univ. Inst. for Nuclear Study). Apr. 2, 1964. 10p.

The statistical relation between range and energy of underground $\mu$-mesons was studied analytically by assuming ionization losses, bremsstrahlung, and pair creation in ground penetration. (R.E.U.)

**28322** (JINR-P-1639) NELOKALNYE POTENTSIALY I VOZMOZHNOE NARUSHENIE BOZE I FERMI STATISTIK. (Non-Local Potentials and Possible Violation of Bose and Fermi Statistics). S. N. Sokolov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). 1964. 4p.

Non-locality of the potential in the Schroedinger equation may cause a qualitative change of solutions. In particular, distinguishable particles may behave in the region of low energies as identical (Bose or Fermi depending on the specific choice of the nonlocal interaction potential). If the observed identity of elementary particles is not absolute, but is connected with some non-local potentials, then high energy experiments may detect the breakdown of Bose and Fermi symmetries of wave-functions. (auth)

**28323** (LA-3066) INTEGRALS OF BETA SPECTRA. George P. Ford and Darleane C. Hoffman (Los Alamos Scientific Lab., N. Mex.). May 1964. Contract W-7405-eng-36. 31p.

Integrals of $\beta^-$ spectra for allowed transitions were calculated for z = 10 to 109 and for maximum kinetic energies from 0.1 to 5.5 Mev at 0.1 Mev intervals. The results are tabulated and can be used for a nongraphical determination of relative abundances of $\beta^-$ spectrum components from their Fermi-Kurie plots. (auth)

**28324** (LNF-64/6) PHOTOPRODUCTION AND NEUTRAL DECAY MODES OF THE $\eta$-PARTICLE. Note No. 234. C. Bacci, C. Mencuccini, G. Penso, R. Querzoli, G. Salvini, V. Silverstrini, and A. Wattenberg (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Mar. 16, 1964. 34p.

The historical background of the pion resonance $\eta$ is given. The photoproduction of the $\eta$ particle on protons at 978 and 939 Mev was observed, using the 1.1-Bev Frascati electron synchrotrons and spark chambers, scintillation, and Cherenkov counters. Neutral decay modes of $\eta$, $3\pi$, radiative, and combined, are discussed. 44 references. (R.E.U.)

**28325** (TID-20702) PROGRESS REPORT FOR A RESEARCH PROGRAM IN EXPERIMENTAL AND THEORETICAL HIGH-ENERGY PHYSICS. David Feldman and Anatole M. Shapiro (Brown Univ., Providence). June 1, 1964. Contract AT(30-1)-2262. 22p.

Progress in various programs on high-energy meson physics is reported, and proposals for work in the following year are made. A list of papers published during the report period is given. (R.E.U.)

**28326** (TID-20705) MEASUREMENT OF THE FORM FACTOR RATIO IN $K^-_{\mu_3}$ DECAY. T. H. Groves, P. R. Klein, and V. VanderBurg (Purdue Univ., Lafayette, Ind.). [1964]. Contract AT(11-1)-123. 12p.

The measurement of the form factor ratio for the three-body leptonic decay of $K^-$ ($K^- \rightarrow \mu^- + \pi^0 + \bar{\nu}$) is reported. The meson($\mu$) energy spectrum was evaluated from 138 events as recorded on bubble chamber photographs. (R.E.U.)

**28327** (TID-20711) ELECTROMAGNETIC PROPERTIES OF THE NEUTRINO. Jeremy Bernstein, Malvin Ruderman (New York Univ., New York); and Gerald Feinberg (Columbia Univ., New York). [1963]. Contracts AT(30-1)-1480 and AT(30-1)-1808. 33p.

A detailed survey of the experimental information on the neutrino charge, charge radius, and magnetic moment was made. Both weak interaction data and astrophysical results can be used to give precise limits to these quantities, independent of the supposition that the weak interactions are charge conserving. (auth)

**28328** (TID-20717) VECTOR MESON PRODUCTION IN MESON-BARYON COLLISIONS. Lu Sun Lio (Northwestern Univ., Evanston, Ill.) and Paul Singer (Columbia Univ., New York). [1963]. Contract AT(30-1)-1808. 40p.

A covariant general treatment of the amplitude for isoscalar vector meson production in pseudoscalar meson-baryon collisions is presented. For the low-energy region, a model is devised by assuming the invariant amplitudes to obey a one-dimensional dispersion relation. The formalism is applied to the reaction (pion + nucleon $\rightarrow$ $\omega$-meson + nucleon), for which the single nucléon and the pion-nucleon cut are taken to dominate the direct channel, while the crossed channels are described by $\rho$-meson and nucleon exchange processes. In the energy range of interest, the pion-nucleon cut is further approximated by the isospin $\frac{1}{2}$ isobars. In the multipole amplitudes of the resonances, for which a Breit-Wigner formula is assumed, only the lower $\omega$ angular momentum is exhibited. The differential and the total cross sections are thus expressed in terms of the coupling constants involved and the resonant partial widths, which are to be determined by comparing with the available experimental data. A satisfactory fit is obtained using only the Born terms as a preliminary step, with the following values for the coupling constants: $(g^2_\pi/4\pi) = 14.4$, $(g^2_{\omega\rho\pi}/4\pi) = 10.5$, $(g^2_\omega/4\pi) = 1.0$, $(g^2_{\rho c}/4\pi) = 0.4$, $(g^2_{\rho m}/4\pi) = 0.8$, and $(g_{\rho m}/g_{\rho c}) = -1.4$. (auth)

**28329** (TID-20718) NOTE ON THE ELECTROMAGNETIC CURRENT IN $SU_3$ SYMMETRY. M. Nauenberg (Columbia Univ., New York). [1963]. Contract AT(30-1)-1808. 10p.

The possible existence of strongly interacting particles that behave like triplets under the SU(3) symmetry group adds a new contribution to the electromagnetic current, part of which transforms like a scalar under SU(3). Some consequences for the electromagnetic properties of baryons and mesons, considered as composite states of these triplets, are examined. (auth)

**28330** (TID-20722) A SCALING LAW FOR HIGH-ENERGY ELASTIC SCATTERING. Robert Serber

(Columbia Univ., New York). [1964]. Contract AT(30-1)-1808. 12p.

A scaling law suggested by an optical model is evaluated for high-energy elastic scattering (p-p, $\bar{p}$-p, $\pi^+$-p, $\pi^-$-p, $K^+$-p, and $K^-$-p) in the range 7 to 20 Bev/c. (R.E.U.)

**28331** (UCRL-2426(Vol.I)(1963 Rev.)) HIGH-ENERGY PARTICLE DATA. VOLUME I. KINEMATICS OF PARTICLES AS A FUNCTION OF KINETIC ENERGY. W. Peter Trower, Beverly Hill Willis, and Charles V. Stableford (California. Univ., Berkeley. Lawrence Radiation Lab.). July 1, 1963. Contract W-7405-eng-48. 122p.

Revised high-energy particle data graphs are given (see also original UCRL-2426, NSA 11: 6867). The energy range for the plots was extended to 100 Bev. The ellipse-plotting graphical method for solution of the relativistic two-body problem is discussed. Dynamics of elementary particle collisions with proton targets are presented graphically. (R.E.U.)

**28332** (UJV-1021/63) MULTIPOL'NOE RAZLOZHENIE AMPLITUDY EFFEKTA KOMPTONA I OPREDELENIE SPOSOBA POLYARIZUEMOSTI. (Multipole Expansion of Compton Effect Amplitude and Determination of Polarity). Peter Pajas (Paias (Československá Akademie Věd. Ústav Jaderného Výzkumu, Řež). [1963]. 16p.

Compton effect amplitudes were expanded into a series of multiple moments. In the case of a particle with ½ spin the expansion contained only dipole and quadrupole electric and magnetic moments. The formulas used for determining particle polarization showed that the polarization differs from zero for inelastic photoproduction. (tr-auth)

**28333** OBSERVATIONS ON THE LAPLACE-LENZ VECTOR. Fritz Schweiger (Universität, Vienna). Acta Phys. Austriaca, 17: 343-6(1964). (In German)

It was shown that the Laplace-Lenz vector can be derived as a conservation principle opposite certain infinitesimal transformations. (tr-auth)

**28334** END-STATE RECIPROCAL EFFECTS IN THE INELASTIC ELECTRON-DEUTERON SCATTERING. H. Latal and P. Urban (Universität, Graz). Acta Phys. Austriaca, 17: 378-88(1964). (In German)

In an expansion of the work of B. Bosco (Phys. Rev., 123: 1072(1961)), an investigation was made to determine if, by the addition of tensor potentials for the inelastic e-d scattering, essential changes are obtained in Bosco's results. It is shown that the correction is on the order of 0.5% and therefore is neglectable. (tr-auth)

**28335** REMARK ON THE ANALOGY OF THE FOLDY-WOUTHUYSEN AND LORENTZ TRANSFORMATIONS. J. Voisin (Universite, Liege). Bull. Soc. Roy. Sci. Liege, 33: 13-16(1964). (In French)

In the case of particles of nonzero mass, analogies have previously been noted between the F-W transformation and the Lorentz transformation from the laboratory system to the rest system. Such an analogy is established between the F-W transformation and some 3-rotation in spin space for the case of the zero-mass neutrino. (D.C.W.)

**28336** CURRENT RESEARCH IN ELEMENTARY PARTICLE PHYSICS. V. Weisskopf (CERN, Geneva). Chim. Chronika (Athens, Greece), 28A: 5-10(1963).

Some general findings on nucleons, such as nuclear field quanta (mesons), antiparticles and their implications, and weak interactions are reviewed, together with recent advances, such as the discovery of two neutrinos, pion complexes, excited states of nucleons, and the lack of a hard core in nucleons. (D.C.W.)

**28337** MEASUREMENT OF THE COEFFICIENT OF BACKWARD SCATTERING FOR ELECTRONS OF 5 TO 30 kev. Elie Weinryb and Jean Philibert (IRSID, Saint-Germain-en-Laye, France). Compt. Rend., 258: 4535-8 (May 4, 1964). (In French)

The experimental conditions for measuring the coefficient $\eta$ using a Castaing probe were determined, together with the necessary corrections to the results. Measurement of $\eta$ as a function of the atomic number Z of the target for 4.5- to 30-kev electrons showed that $\eta$ increases with Z and decreases with incident electron energy. The variation of $\eta$ with Z is linear up to $Z \simeq 30$, then it becomes parabolic. (D.C.W.)

**28338** ON THE NEAREST REAL SINGULARITIES OF A SINGLE-LOOP FEYNMAN DIAGRAM. M. Barmawi (Bandung Inst. of Tech., Netherlands). Madjalah Inst. Tekn. Bandung Proc., 2: 129-39(1963).

The nearest real singularities of the production amplitude corresponding to a single loop Feynman diagram is discussed. It is shown that the Landau condition and the positiveness of the Feynman parameter are not sufficient for the part of Landau curve to be the nearest real singularity. The additional condition is the generalized Karplus, Sommerfield, and Wichmann condition, originally found in the 3-point function. The consequences of this additional condition is discussed and related to the Blankenbeckler-Nambu conjecture. The discussion is also applicable to an arbitrary Feynman diagram. (auth)

**28339** ON A MODIFICATION OF THE S-MATRIX REDUCTION FORMALISM WHICH TOUCHES ON THE ASYMPTOTIC CONDITIONS. E. Wieczorek. Monatsber. Deut. Akad. Wiss. Berlin, 5: 670-5(1963). (In German)

An s-matrix reduction formula of the type developed by Lehmann, Symanzik, and Zimmermann was modified. (M.C.G.)

**28340** COMPARISON OF p-p AND n-n FINAL STATE INTERACTIONS. R. J. N. Phillips (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Nucl. Phys., 53: 650-6(May 1964).

The differences between pp and nn final state interaction effects are discussed and illustrated for the case of a short-range reaction mechanism and for the long-range case of nucleon-deuteron charge exchange. (auth)

**28341** DISPERSION RELATIONS FOR SCATTERING BY SPIN-DEPENDENT POTENTIALS. Muhammad Jameel (Univ. of Edinburgh). Nucl. Phys., 56: 353-79(Aug. 1964).

Dispersion relations for the mutual scattering of two spin-half particles are proved by studying the analytic and asymptotic properties in the complex energy plane of the outgoing wave Green function of the hamiltonian. The interaction considered is the most general spin-dependent potential which is invariant under rotations, space reflection, time reversal and Galilean transformations and is no more than linear in the relative momentum; the necessary asymptotic behavior of each of the four terms in such a potential is examined. The generalization of the results to particles of higher spin is discussed. (auth)

**28342** UNITARY SUMMETRY AND PARITY CONSERVATION. A. Marzollo and C. Scarinci (Università, Padua and Istituto Nazionale di Fisica Nucleare, Padua). Nucl. Phys., 56: 380-4(Aug. 1964).

Parity conservation is deduced for an interaction lagrangian that is invariant under the transformations of the $SU_3$ group. If PC invariance is assumed for such a lagrangian, the separate P invariance can be deduced as a consequence of unitary symmetry. (auth)

**28343** RE-DETERMINATION OF THE SCATTERING CONSTANT AT LONG CELL LENGTHS. A. A. Kamal, G. K. Rao, and Y. V. Rao (Osmania Univ., Hyderabad, India). Nuovo Cimento (10), 32: 863-72(May 16, 1964).

The scattering constant K was determined in G-5 emulsions from multiple scattering measurements on individual beam tracks of 17 Bev/c mesons. Reliable values of K for cell lengths between 2 mm and 4 cm were obtained. K is fairly constant in this region and lies below the theoretical curve for cells larger than 1 cm. The correlation ratio of second and third differences ($\rho_{33}$) for Coulomb scattering is about 7 percent higher than the theoretical value. The corresponding ratios between higher differences ($\rho_{43}$ and $\rho_{54}$) are in good agreement. It is shown that the distribution of second differences with $4\overline{D}$ cut off is Gaussian (as expected from theory), over the entire range of cells considered. Relative scattering measurements made on closely spaced pairs of beam tracks of 24 Bev/c and 27 Bev/c protons and 17 Bev/c $\pi$ mesons indicate that the measurements may depend on the general level of spurious scattering present in the pellicles. (auth)

**28344** TRANSVERSE MOMENTUM OF SECONDARY PARTICLES PRODUCED IN HIGH-ENERGY NUCLEAR INTERACTIONS. P. L. Jain, H. C. Glahe, J. D. Rinaldo, and P. D. Bharadwaj (State Univ. of New York, Buffalo). Nuovo Cimento (10), 32: 873-9(May 16, 1964).

The spectra of transverse momentum of pions, kaons, protons and $\Sigma$ particles produced by 6.3 Bev protons, 16.3 Bev/c pions, and 28 Bev/c protons in nuclear emulsion are presented. Shapes of the observed momentum spectra seem to be independent of the type of particle produced in an interaction. The average transverse-momentum values for heavy particles are slightly greater than those for light ones. Present results are compared to previous experimental work and predictions of the theories of Fermi, Heisenberg, and Landau. (auth)

**28345** THREE-QUANTUM ANNIHILATION OF POSITRON-ELECTRON PAIRS IN ALKALI HALIDES. A. Gainotti, E. Germagnoli, G. Schianchi, and L. Zecchina (Universita, Italy). Nuovo Cimento (10), 32: 880-5(May 16, 1964).

The probability $p_3$ of three-quantum annihilation of positron-electron pairs was measured for a number of alkali halides. While $p_3$ for fluorides is consistent with the hypothesis of a prompt positron-electron annihilation, for other halides $p_3$ is much larger than $^1/_{372}$. This result is compared with other recent findings. (auth)

**28346** REGGE CUTS IN A NONRELATIVISTIC THREE-BODY PROBLEM INVOLVING SEPARABLE POTENTIALS. M. McMillan (Massachusetts Inst. of Tech., Cambridge). Nuovo Cimento (10), 32: 919-38(May 16, 1964).

The problem of two particles interacting with a fixed scattering center via separable nonlocal potentials is considered; the full one-particle and free two-particle Green's functions can be written in closed forms. The two-particle function regarded as a function of complex angular momenta has energy-dependent branch points. To show the singularities of this function, the problem of one particle impinging upon a bound state of the second particle and the fixed scattering center is considered. The interparticle potential is taken to be separable, in which case the total wave function can be written in closed form. The partial-wave elastic scattering amplitude is shown to have Regge poles and a Regge cut. The intimate connection between the discontinuity across this cut and the slope of the Regge trajectory in the subsystem consisting of the projectile and the fixed scattering center is pointed out. (auth)

**28347** ON THE ANALYTIC PROPERTIES AND ASYMPTOTIC BEHAVIOUR FOR LARGE l OF PARTIAL-WAVE AMPLITUDES IN MANY-CHANNEL POTENTIAL SCATTERING. M. H. Choudhury (Univ. of Edinburgh). Nuovo Cimento (10), 32: 943-54(May 16, 1964).

The analytic properties and asymptotic behavior for large l of partial-wave amplitudes in many-channel scattering are studied for a superposition of Yukawa potentials. The methods used are based on Fredholm theory. It is shown that the amplitudes have the correct asymptotic behavior along the imaginary axis. (auth)

**28348** REGGE POLES IN THE PRESENCE OF A HARD CORE. S. Ciulli, Gr. Ghika, and M. Stihi (Inst. for Atomic Physics, Bucharest). Nuovo Cimento (10), 32: 955-70 (May 16, 1964).

A hard-core potential is introduced in addition to the Yukawa potential to obtain the analytic continuation of the S matrix in the left half plane. The Watson transform can not be simply performed because of an essential singularity at infinity. However, use of the relation between the two kinds of Legendre functions avoids this difficulty; besides the pole sum of the Regge terms, an integral which can be evaluated by the steepest descent method is obtained. The nature of the singularity for hard-core radius = 0 is studied. The position of the first poles and the corresponding residues in the case of weak potentials are derived. (auth)

**28349** POLARIZATION EFFECTS IN ELASTIC LEPTON-PROTON ELECTROMAGNETIC SCATTERING. F. Guérin and C. A. Piketty (Faculte of Sciences, Orsay) France). Nuovo Cimento (10), 32: 971-84(May 16, 1964).

Polarization effects in lepton-proton elastic scattering are calculated using an isobaric model. The maximum effects stay around $-0.5\%$ for incident lepton laboratory momenta of the order of 1000 Mev/c and for large momentum transfer. (auth)

**28350** RADIATIVE REACTION AND A POSSIBLE THEORY FOR THE MUON. G. Rosen (Southwest Research Inst., San Antonio, Tex.). Nuovo Cimento (10), 32: 1037-45 (May 16, 1964).

In classical electron theory, the equation of motion with radiative reaction features a higher order differential structure and a characteristic length. Consideration is given to an analogous quantum equation of motion. In addition to the wave function for an ordinary electron, that for a muon, an electron quantum state that is excited dynamically by radiative reaction, appears as a solution to this new quantum equation of motion. It is shown that interaction theory based on this quantum equation is compatible with conventional quantum electrodynamics generalized to include the muon. (auth)

**28351** A MANDELSTAM REPRESENTATION IN HARD-CORE POTENTIAL SCATTERING. O. Brander (Chalmers Tekniska Högskola, Göteborg). Nuovo Cimento (10), 32: 1059-66(May 16, 1964).

The difference between the scattering amplitudes for scattering from a potential with a hard core and from the hard core alone is studied. Provided the potential outside the hard core is a superposition of Yukawa potentials, it is shown that this difference satisfies a Mandelstam representation of conventional form. (auth)

**28352** NOTE ON THE "BOOTSTRAP" EXPLANATION OF THE $\mathcal{N}$ AND $\mathcal{N}_{33}$. B. Diu and H. R. Rubinstein (Faculte des Sciences, Orsay, France). Nuovo Cimento (10), 32: 1103-6(May 16, 1964).

As the relativistic calculations already performed in

the $\pi$-$A$ system do not prove that the $A$ and the $A_{33}$ are simultaneously composite, the corresponding bootstrap equations are solved in the static model. The solution is found without need of computers, and is reasonable. (auth)

**28353** DECAY PARAMETERS OF $\Omega^-$. W. W. Wada (Northwestern Univ., Evanston, Ill.). Nuovo Cimento (10), 32: 1113-16(May 16, 1964).

A possible method of determining nonleptonic decay parameters of $\Omega^-$ from experimental results, when a number become available, is presented. It is proved that the longitudinal polarization of the decay hyperon equals the negative of the asymmetry parameter. The result is applied to the parity-conserving decay of $Y_1^*$. (M.J.T.)

**28354** VIOLATION OF CONSERVATION OF STRANGENESS-CHANGING CURRENT. Riazuddin (Univ. of Rochester, N. Y.). Nuovo Cimento (10), 32: 1122-8(May 16, 1964).

It is suggested that there is universality in weak interactions for the vector current in the exact symmetry limit (where the vector current is exactly conserved) and that just as the $\xi$ particle, which breaks the isotopic-spin symmetry, may make the effective $G_\nu$ smaller than $G_\mu$ in strangeness-conserving processes, the $\chi$ meson, which breaks the unitary symmetry, may make the effective coupling constant in strangeness-changing leptonic processes smaller than the universal vector weak coupling constant. This explanation enables the correlation of data on $K_{13}$ decay, which involves only the vector part of the current. It is thus attempted to give a dynamical origin to the reduced strength of the strangeness-changing processes relative to the strangeness-conserving processes. (M.J.T.)

**28355** POSSIBLE EXISTENCE OF A SUPER-$\Omega$. H. Hoegaasen (Institutt for Teoretisk Fysikk, N.T.H., Trondheim, Norway). Nuovo Cimento (10), 32: 1129-30 (May 16, 1964).

Indications of the existence of a super $\Omega$, called $\Omega_2$, with $I = 0$, $Y = -4$, and thus $Q = -2$, at about 2150 Mev, are pointed out. (M.J.T.)

**28356** ENERGY-MOMENTUM RELATION OF ELECTRONS INTERACTING WITH OPTICAL PHONONS. G. Whitfield (Princeton Univ., N. J.) and R. D. Puff. Phys. Letters, 10: 9-10(May 15, 1964).

The qualitative behavior of the energy-momentum relation E(p) for an electron interacting with optical phonons is discussed. It is concluded that the function is proportional to $p^2$ for small p but becomes horizontal as $E(p) - E(0)$ approaches the optical phonon energy. (C.E.S.)

**28357** A NEW DIAGRAM FOR PION-NUCLEON RESONANCES. G. Hoehler (Technische Hochschule, Karlsruhe, Ger.). Phys. Letters, 10: 118-19(May 15, 1964).

It is shown that information on $\pi$-N resonances can be obtained from a graph in which the contribution of a resonance is a circle as long as the energy dependence of the absorption parameter can be neglected. A graph of the quantity that depends on the momentum, forward scattering amplitude, and the absorption cross section is illustrated. (C.E.S.)

**28358** INELASTIC ELECTRON-DEUTERON-SCATTERING. K. Hoelzl, G. Saller, and P. Urban (Universität, Graz). Phys. Letters, 10: 120-2(May 15, 1964).

Calculations of the cross sections for inelastic e-d scattering were reported. The interaction hamiltonian was obtained by a Foldy-Wouthuysen-transformation. The effects of final state interactions were calculated. The D-state was treated without approximation, and the influence of the deuteron wave function on the cross section was investigated. (C.E.S.)

**28359** ON THE UPPER LIMIT OF THE $\pi$-N COUPLING CONSTANT. N. N. Meyman and A. A. Slavnov (Inst. of Theoretical and Experimental Physics, Moscow and Mathematical Inst., Moscow). Phys. Letters, 10: 124-6(May 15, 1964).

The upper limit of the $\pi$-N coupling constant is derived from an inequality concerning the $\pi$-N vertex function. (C.E.S.)

**28360** EXPERIMENTAL RESULTS ON $\pi^+\pi^-$ PRODUCTION BY 18.1 Gev/c $\pi^-$. G. Bellini (Università and I.N.F.N., Milan), E. Fiorini, P. Negri, J. Hennessy, J. J. Veillet, J. Crussard, J. Ginestet, and A. H. Tran. Phys. Letters, 10: 126-8(May 15, 1964).

The reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + n + x\pi^0$ was studied in a heavy liquid bubble chamber exposed to an 18.1-Bev/c $\pi^-$ beam. The meson ($\rho$) production cross section was determined and the mass distributions of the ($\pi^-\pi^+$) system were measured. (C.E.S.)

**28361** A VECTOR-SPINOR BOOTSTRAP AS AN IDENTITY. M. Gell-Mann and F. Zachariasen (California Inst. of Tech., Pasadena). Phys. Letters, 10: 129-30 (May 15, 1964).

The first non-trivial approximation that the Lagrangian field theory of spin $\frac{1}{2}$ fermions and neutral vector mesons interacting through a conserved current has the property that the elementary spinor particle lies on a Regge trajectory. It is pointed out that this feature of the spinor-vector field theory also has interesting implications when phrased in terms of S-matrix theory in which it is assumed that there are no elementary objects and that all particles are created by a bootstrap mechanism. A model bootstrap calculation of a spinor particle (nucleon) as a bound state of itself and a neutral vector meson is discussed. (C.E.S.)

**28362** SPECULATIONS ON $J = \frac{3}{2}$ BARYONS. J. J. Sakurai (Università, Rome and Univ. of Chicago). Phys. Letters, 10: 132-4(May 15, 1964).

A unitary multiplet assignment for the $J = \frac{3}{2}$ baryons based on hypercharge reflection invariance is proposed. The validity and predictions of this assignment are discussed. (C.E.S.)

**28363** FORWARD $\pi^-$p CHARGE EXCHANGE SCATTERING BETWEEN 0.8 AND 1.9 Gev. P. Borgeaud (CEN, Saclay, France), C. Bruneton, Y. Ducros, et al. Phys. Letters, 10: 134-7(May 15, 1964).

A study of the $\pi^-$-p charge exchange scattering in the forward direction by a spark chamber technique is discussed. A dispersion relation was investigated in a region where the imaginary part of the forward scattering amplitude is expected to go twice through zero. The $\pi^- + p \rightarrow \pi^0 + n$ events were detected through the observation of the showers produced by the two decay photons of $\pi^0$ in a spark chamber. Measurements were carried out at 15 energies between 0.8 and 1.9 Bev. (C.E.S.)

**28364** EXPERIMENTAL TEST OF A DISPERSION RELATION IN THE Gev REGION. B. Amblard (CEN, Saclay, France), P. Borgeaud, Y. Ducros, et al. Phys. Letters, 10: 138-41(May 15, 1964).

The measurement of the $\pi$-N charge exchange scattering at zero degrees provides a test of the dispersion relations for forward scattering amplitudes. Calculated values of the real part of the scattering amplitude are compared with experimental values derived from the forward charge ex-

change differential cross sections and total cross sections for $\pi^{\pm}$-p interactions at 760 to 1655 Mev. (C.E.S.)

**28365** IS THE $K^0$-MESON ELECTRICALLY NEUTRAL? Y. Yamaguchi (Tokyo Univ.). Phys. Letters, 10: 141-2 (May 15, 1964).

Possible effects that may be due to the electrical non-neutrality of the meson ($K^0$) are discussed. (C.E.S.)

**28366** DECAY MODES OF THE $\Omega^-$. S. L. Glashow and R. H. Socolow (Harvard Univ., Cambridge, Mass.). Phys. Letters, 10: 143-5(May 15, 1964).

Predictions for the rates and branching ratios of the many distinct $\Omega^-$ decay modes are presented. The lifetime of the $\Omega^-$ is also calculated. (C.E.S.)

**28367** MEASUREMENT OF THE $Y_1^*(1385)$ SPIN AND PARITY. E. Malamud (CERN, Geneva) and P. E. Schlein. Phys. Letters, 10: 145-8(May 15, 1964).

The spin and parity of the $Y_1^*$ was determined by investigating the sequence $Y_1^{*\pm} \rightarrow \Lambda + \pi^{\pm}$ and $\Lambda \rightarrow \pi^-$ in events produced in the reaction $K^- + p \rightarrow Y_1^{*\pm} + \pi^+$ by a meson ($K^-$) beam in a hydrogen bubble chamber at 1.455 Bev/c. (C.E.S.)

**28368** THE EFFECT OF THE $\rho$-MESON IN $J = 1/2$, $T = 1/2$ PION-NUCLEON SCATTERING PHASE-SHIFT. A. Boehm and H. A. Rashid (Atomic Energy Centre, Lahore, Pakistan). Phys. Letters, 10: 151-2(May 15, 1964).

A modification of previous representations that improves the theoretical $J = 1/2$, $T = 1/2$ $\pi$-N scattering phase shifts and brings them closer to the experimental data is presented. It is assumed that the low-energy t-channel is dominated by the meson ($\rho$). (C.E.S.)

**28369** ELECTROMAGNETIC $\Lambda$-$\Sigma^0$ MIXING AND CHARGE SYMMETRY FOR THE $\Lambda$-HYPERON. R. H. Dalitz (Oxford Univ.) and E. Von Hippel. Phys. Letters, 10: 153-7(May 15, 1964).

The expression for the $\Sigma\Lambda$ element of the electromagnetic mass matrix is discussed. This matrix element implies the existence of appreciable mixing between the isospin-pure $\Sigma^0$ and $\Lambda$ states. The mixing parameter is quite large relative to the natural parameter for electromagnetic self-energies, and some of the consequences of this fact are considered. Charge symmetry in $\Lambda$ production, $\Lambda \rightarrow N\pi$ decay, $\Lambda \rightarrow \Lambda + \pi^0$ coupling, and charge symmetry for $\Lambda$-N forces are discussed. (C.E.S.)

**28370** PHOTOPRODUCTION OF $\pi^+$ MESONS FROM HYDROGEN AT CONSTANT MOMENTUM TRANSFER. B. H. Patrick, J. M. Paterson, J. G. Rutherglen, and J. Garvey (Univ. of Glasgow). Phys. Letters, 10: 157-9 (May 15, 1964).

The differential cross section for the reaction $\gamma + p \rightarrow \pi^+ + n$ was measured between 190 and 250 Mev at angles corresponding to conditions of constant momentum transfer. (C.E.S.)

**28371** EXACT CALCULATION OF BREMSSTRAHLUNG FROM POLARIZED ELECTRONS. J. D. Rozics and W. R. Johnson (Univ. of Notre Dame, Ind.). Phys. Rev., 135: B56-60(July 13, 1964). (TID-20173)

The production of bremsstrahlung by the interaction of polarized electrons with the Coulomb field of a nucleus is considered. An exact calculation of the angular distribution of the outgoing photons and the azimuthal asymmetry in this distribution is presented. Numerical calculations were done for an incident electron energy $W_1 = 1.25m$, a photon energy $k = 0.75\ (W_1 - m)$, and a nuclear charge $Ze = 79e$. (auth)

**28372** "OLD" RESONANCE MODEL FOR $3\pi$ DECAYS OF K AND $\eta$. A. N. Mitra and Shubha Ray (Univ. of Delhi). Phys. Rev., 135: B146-51(July 13, 1964).

A phenomenological model of a $\pi$-$\pi$ resonance in I = 0, proposed previously, is re-examined in the context of the present experimental data. It is found that the model satisfactorily explains all the available features of $\tau$ and $\tau'$ decays if the resonance occurs at an energy around 400 Mev with a width 85-90 Mev. The corresponding parameters with a somewhat smaller width (~75-80 Mev) also give satisfactory agreement with the experimental results for $\eta$ decay. This model corresponds to a repulsive I = 0 $\pi$-$\pi$ interaction at low energies and is therefore not in disagreement with the earlier dispersion theoretical predictions for $\tau$ decay, using final-state interactions. It also has a strong resemblance to the $\sigma$ model of Brown and Singer. (auth)

**28373** TEST OF NORMAL STATISTICS FOR K MESONS. Saul Barshay (Rutgers Univ., New Brunswick, N. J.). Phys. Rev., 135: B152-3(July 13, 1964).

A direct experimental test of the statement that mesons(K) obey Bose statistics has not been carried out. For a certain class of reactions, a purely geometrical experimental consequence of the statement that the wave function for a system of two spin zero mesons(K) is either completely symmetric or completely antisymmetric under simultaneous interchange of the isotopic spin and spatial variables of the two particles is pointed out. The test can be used to investigate the possibility of a more general kind of statistics (parastatistics) for mesons(K), in which case the above experimental manifestation of complete symmetry or complete antisymmetry would not, in general, hold. (auth)

**28374** MONTE CARLO CALCULATIONS APPLIED TO A DETERMINATION OF FOUR-MOMENTUM TRANSFER IN ULTRA-HIGH ENERGY INTERACTIONS. R. D. Settles (Louisiana State Univ., Baton Rouge). Phys. Rev., 135: B153-60(July 13, 1964).

Four-momentum transfer, between two groups of particles produced in ultra-high energy interactions is studied using 3000-Bev Monte Carlo jets generated from information based largely on experimentally determined average properties of $10^{12}$-ev jets. First, a parameter introduced by Hasegawa for measuring a deliberate underestimate of this four-momentum transfer is calculated using the Monte Carlo jets. In general, the results agree with the experimental findings of Fujioka, in that the values of this parameter are concentrated above one nucleon mass. Detailed differences between the Monte Carlo and the experimental distributions may be explained by differences between properties of the Monte Carlo and the experimental jets after clarification of the properties of the parameter. Next, after assuming values of the masses and the transverse momenta of the baryons surviving the collision, the actual value of the four-momentum transfer between the two groups of the produced particles for the Monte Carlo jets was calculated. The Hasegawa parameter is found to underestimate this actual value by a factor of about $0.6 \pm 0.2$, the limits defining the approximate 68% confidence interval for statistical fluctuations of individual measurements about the mean factor 0.6. Finally, the distribution of this actual value itself shows a mean around two nucleon masses, indicating that jets having average properties like the Monte Carlo jets belong to a different class of events from those encompassed by "linked-peripheral" models for which virtual meson($\pi$) transfer predominates. (auth)

**28375** POSSIBLE METHOD FOR ISOLATING THE $K^*$-EXCHANGE CONTRIBUTION TO THE REACTION $\gamma + p \rightarrow K^+ + \Lambda$. S. Barshay (Rutgers Univ., New Brunswick, N. J.) and M. Kawaguchi. Phys. Rev., 135: B161-5 (July 13, 1964).

It is pointed out that for the interaction $\gamma + p \rightarrow K^+ + \Lambda$ induced by linearly polarized photons, the differential cross section is independent of the $K^+$-exchange amplitude when the plane of scattering (the plane containing the initial and final momenta) is at 90° to the plane of polarization (the plane containing the photon polarization and momentum). Measurement and analysis of this cross section thus provides a relatively direct means of studying the unknown effects of the vector $(K^*)^+$ and of extracting information on the vector and tensor factors associated with its coupling to $(p,\Lambda)$. A detailed study is made of this possibility within the framework of a particular model for the reaction. The result concerning the differential cross section in the 90° plane is general; for example, in the reaction $\gamma + p \rightarrow \pi^+ + n$, the differential cross section in the 90° plane does not contain the $\pi^+$-exchange amplitude, but does contain the vector $\rho^+$-exchange amplitude. (auth)

**28376** ELECTROMAGNETIC CORRECTIONS TO MUON AND BETA DECAYS WHEN MEDIATED BY A VECTOR BOSON. David Bailin (Princeton Univ., N. J.). Phys. Rev., 135: B166-80(July 13, 1964).

The radiative corrections to the weak decays were calculated using two electromagnetic formalisms for the vector bosons. The energy spectrum for the electrons from muon decay is obtained and is found to reduce to the old form, obtained using the four fermion interaction, when the mass of the boson becomes infinite. The effective value of the Michel parameter is calculated. It seems unlikely that the electromagnetic effects of a boson would be observed through a study of the spectrum shape. The calculated spectrum satisfies Kinoshita's theorem. The results for muon decay are independent of the vector meson formalism employed. It is found that the bosons can reduce the corrections to the $^{14}O$ decay lifetime to 1.2%, although the reduction depends upon the choice of formalism. The boson mass provides an effective cutoff which renders the over-all correction to the lifetime finite. This was not previously the case. Finally it is concluded that a vector meson can explain the muon lifetime discrepancy, but not if the current indications on its mass prove to be correct. (auth)

**28377** DIFFRACTION WIDTH IN TERMS OF $f^0$ AND THE RESIDUE OF THE POMERANCHUK POLE. Bipin R. Desai (Univ. of Wisconsin, Madison). Phys. Rev., 135: B180-2(July 13, 1964). (TID-20087)

At a sharp resonance, the phase of a Regge residue $\beta(t)$ should be essentially a multiple of $2\pi$. The value it takes determines to a large extent the falloff rate of $\beta$ and of the reduced residue $\gamma = \beta/\nu^\alpha$ for $t \leq 0$. If $f^0$ lies on the Pomeranchuk trajectory and if the phase there is $2\pi$ then it turns out that $\gamma(t)$ falls of exponentially for small $-t$ with a width comparable to the one deduced from the widths of the high-energy diffraction peaks, and for large $-t$, $\gamma(t)$ has a power fall-off. On the other hand, if the phase at $f^0$ remains small then the width is at least an order of magnitude larger. The latter case is indicated on the basis of the potential theory results. However, it is possible that the former may be a purely relativistic phenomenon peculiar to the Pomeranchuk pole in which case the Regge-pole hypothesis would be consistent with the high-energy experiments. (auth)

**28378** LIFETIMES OF THE $\Xi^-$ AND $\Xi^0$ HYPERONS. J. Richard Hubbard, J. Peter Berge, George R. Kalbfleisch, Janice B. Shafer, Frank T. Solmitz, M. Lynn Stevenson, Stanley G. Wojcicki, and Peter G. Wohlmut (Univ. of California, Berkeley). Phys. Rev., 135: B183-7(July 13, 1964). (UCRL-10819)

The lifetimes of hyperons ($\Xi^-$) and ($\Xi^0$) were determined to be $1.69 \pm 0.07$ and $2.5 \times 10^{-10}$ sec, respectively. The ratio of the $\Xi^0$ decay rate to the $\Xi^-$ decay rate $(0.68 \pm 0.10)$ is within two standard deviations of the $|\Delta T| = 1/2$ prediction of 0.5. (auth)

**28379** WEAK CORRECTIONS TO THE MAGNETIC MOMENTS OF LEPTONS. R. A. Shaffer (Vanderbilt Univ., Nashville). Phys. Rev., 135: B187-9(July 13, 1964).

The contribution of the weak interactions to the magnetic moments of the leptons is calculated. An intermediate vector boson is assumed, and lowest order effects are calculated. The radiative corrections to these results are estimated by making use of the summation technique introduced by Lee. The contributions are small compared to the uncertainties in the experimental values of the magnetic moments. For the muon the changes in the magnetic moment are at least an order of magnitude smaller than the contributions of the strong interactions. If the muon's neutrino has a relatively large mass, its induced magnetic moment will affect the neutrino scattering cross sections calculated by Bernstein and Lee. (auth)

**28380** KAON DECAYS AND PION STATISTICS. H. C. von Baeyer (Vanderbilt Univ., Nashville). Phys. Rev., 135: B189-90(July 13, 1964).

Selection rules for nonleptonic decays of kaons are given under different assumptions about the statistics of pions. It is found that the observed decay modes are compatible only with the assumption that pions are bosons. (auth)

**28381** $K^+$-PROTON ELASTIC SCATTERING AT 910 Mev/c; POLARIZATION OF THE RECOIL PROTONS. Warner Hirsch and George Gidal (Univ. of California, Berkeley). Phys. Rev., 135: B191-8(July 13, 1964). (UCRL-10950; UCRL-10950 Rev.)

A propane bubble chamber was used to study the elastic $K^+$-p interaction at 910 Mev/c. This is the region of transition from the isotropy in angular distribution found below 810 Mev/c to the rapidly increasing anisotropy above 1 Bev/c. Results based on 1154 events show that the series $(1 + a\cos\theta_K^{c.m.})$ can fit the angular distribution with $a = 0.18 \pm 0.05$. Polarization was measured on the secondary proton by using 53 p-p and 41 p-C recoils in the liquid of the chamber. The results of a phase-shift analysis incorporating these polarization data are presented. (auth)

**28382** SMALL-ANGLE MULTIPLE SCATTERING OF FAST CHARGED PARTICLES USING MOLIERE SCREENING. Robert D. Reed and John S. Nodvik (Univ. of Southern California, Los Angeles). Phys. Rev., 135: B199-202 (July 13, 1964).

The Dalitz formula for the second Born approximation for the elastic-scattering cross section of an electron by a Yukawa potential is extended to a potential represented by a sum of three such terms. This result is used to obtain the distribution function for multiple scattering following the method of Bethe and Nigam, Sundaresan, and Wu. The 1/e widths of the distribution function thus obtained are compared to the experimental results of Hanson. (auth)

**28383** FUNCTIONAL ANALYSIS AND SCATTERING THEORY. M. Scadron, S. Weinberg, and J. Wright (Univ. of California, Berkeley). Phys. Rev., 135: B202-7(July 13, 1964). (UCRL-11329)

The nonrelativistic scattering problem is formulated as an integral equation with a kernel which is completely continuous for all energies. A rigorous justification is then given for the Fredholm method, quasiparticle method, and, for weak enough interactions, the Born expansion. An explicit lower bound is also given for the radius of convergence of the Born series and of the Born series modified by the introduction of quasiparticles. It is shown that all these expansions converge uniformly in the physical region of energy and momentum transfer. (auth)

**28384** NEW FORM OF STRIP APPROXIMATION. Geoffrey F. Chew and C. Edward Jones (Univ. of California, Berkeley). Phys. Rev., 135: B208-13(July 13, 1964). (UCRL-10992)

A detailed set of bootstrap equations is formulated for zero-spin "external" particles, based on a combination of the N/D method with the superposition of top-ranking Regge poles in all three reactions of a four-line connected part. The contribution from each pole arises from a distinct strip in the Mandelstam representation so that double counting is avoided. Only real values of l with $l \leq 1$ need be considered in the bootstrap calculation. The amplitude emerging from the N/D equations is meromorphic in the right-half l plane, and the Regge poles approach high-energy limits that are dynamically determined and, in some cases, may lie to the right of l = 0. The reduced residues vanish in the high-energy limit. (auth)

**28385** CONSISTENCY OF THE STRIP APPROXIMATION. C. Edward Jones (Univ. of California, Berkeley). Phys. Rev., 135: B214-19(July 13, 1964). (UCRL-11167)

An investigation is made to determine those properties demanded of the Regge-pole formulas used by Chew and Jones in order to ensure the consistency of the strip approximation. The asymptotic behavior of the Regge parameters based on the dynamical equations is also studied in relation to the same question. It is concluded that the dynamical equations appear capable of producing solutions that are essentially self-consistent with the strip approximation that was used as an input. The Chew-Jones Regge-pole formula is also compared with one suggested previously by Khuri. (auth)

**28386** POSSIBLE EXISTENCE OF A BOSON ICOSUPLET. B. W. Lee (Univ. of Pennsylvania, Philadelphia), S. Okubo, and J. Schecter. Phys. Rev., 135: B219-21 (July 13, 1964).

It is pointed out that the resonance ($B_1$) of the $\pi$-$\omega$ system at 1220 Mev and the resonance ($B_2$) of the $\pi$-$\rho$ system at 1200 Mev may form parts of an icosuplet consisting of a boson decuplet and its charge conjugate. Mixing of the two isotriplets in the decuplet and the conjugate decuplet is noted: $B_1$ and $B_2$ which are eigenstates of the operator G are linear combinations of isotriplets in the $\{10\}$ and $\{10\}^*$ representations. Consequences of this assumption are explored. The possibility that the K-$\pi$-$\pi$ resonance at 1175 Mev may belong to this icosuplet is also discussed. (auth)

**28387** PERTURBATION ANALYTICITY AND AXIOMATIC ANALYTICITY. I. CONNECTION OF THE LANDAU SINGULARITY MANIFOLD WITH KALLEN $\Xi_n(t)$ MANIFOLD AND JOST DANAD MANIFOLD. Alfred C. T. Wu (Univ. of Michigan, Ann. Arbor). Phys. Rev., 135: B222-9(July 13, 1964).

For a class of Feynman graphs $G_n$ (single-loop diagrams with all internal diagonals), the p-space perturbation Landau singularity manifolds are shown to be formally of the same structure as the Källén $\Xi_n(t)$ manifolds for the x-space axiomatic primitive domain. The boundary of the Landau manifold is then shown to be the (DANAD)′ manifold. The relation between the (DANAD)′ and the Jost (DANAD) manifold is a precise generalization of what exists between the $F'_{kl}$ and $F_{kl}$ surfaces of Källén and Wightman. Since the (DANAD)′ defines a natural domain of holomorphy, the axiomatic envelope of holomorphy cannot be expected to be continuable beyond (DANAD)′. This (DANAD)′ result furnishes a specific conjecture to part of the envelope of holomorphy. (auth)

**28388** PERTURBATION ANALYTICITY AND AXIOMATIC ANALYTICITY. II. HANKEL TRANSFORMS. Alfred C. T. Wu (Univ. of Michigan, Ann Arbor). Phys. Rev., 135: B230-2(July 13, 1964).

For a class of Feynmann graphs $G_n$, the perturbation analyticity over the external variables is studied with the aid of Hankel transformations over the internal mass parameters. Formal connection with the axiomatic analyticity is thereby established. (auth)

**28389** $\pi^-$-p INTERACTIONS AT 604 Mev. C. N. Vittitoe, B. R. Riley, W. J. Fickinger, V. P. Kenney, J. G. Mowat, and W. D. Shephard (Univ. of Kentucky, Lexington). Phys. Rev., 135: B232-40(July 13, 1964).

The interactions of 604-Mev mesons($\pi^-$) in a hydrogen bubble chamber were systematically analyzed. In 33000 pictures a total of 8052 usable events were found, corresponding to cross sections of 18.9 ± 1.3 mb for $\sigma$ (elastic), 4.98 ± 0.54 mb for $\sigma(\pi^-p\pi^0)$, 7.87 ± 0.91 mb for $\sigma(\pi^-n\pi^+)$, 14.0 ± 1.0 mb for $\sigma$ (neutrals), with $\sigma$ (two-pion production) <0.2 mb, for a total cross section of 45.9 ± 1.9 mb at this energy. The angular distribution for elastic scattering was fitted with a fifth-order polynomial in $\cos\theta$ which gave a value of $d\sigma/d\Omega(0°)$ consistent with dispersion theory. The $\pi$-$\pi$ effective mass distributions for both single-pion production channels showed pronounced peaking at high mass values, strongly inconsistent with simple isobar-production kinematics. Simple one-pion exchange does not appear to play a significant role. (auth)

**28390** DESCRIPTION OF A PARTICLE WITH ARBITRARY MASS AND SPIN. D. L. Weaver, C. L. Hammer, and R. H. Good, Jr. (Ames Lab., Ames, Iowa). Phys. Rev., 135: B241-8(July 13, 1964). (IS-791)

A Lorentz covariant description of a particle and antiparticle with spin s = 0, ½, 1, ··· and finite rest mass is given. The wave function has 2(2s + 1) components so that no auxiliary conditions are needed. The basic idea is to postulate the rest-system Hamiltonian and make the Lorentz transformation to the laboratory system. An algorithm which is a generalization of the Foldy-Wouthuysen transformation is found for constructing the laboratory-system Hamiltonian and polarization operators. (auth)

**28391** POSSIBLE CONNECTIONS BETWEEN THE FERMION TRAJECTORIES. Ismail A. Sakmar (Univ. of California, Santa Barbara). Phys. Rev., 135: B249-52 July 13, 1964).

The Regge poles appearing in the odd and even continuations of the meson-baryon scattering amplitudes as a function of the energy are investigated from the point of view of relating different fermion trajectories. Many of the existing strange particle resonances with odd and even parity can be related, while there are no $\pi$-N resonances with the proper quantum numbers which can be related within this scheme. The expected form of the trajectories is given in the complex J plane and also as Re $\alpha$ (W) and Re $\alpha$ ($W^2$), the last one corresponding to the Chew-Frautschi diagram. With the discovery of new resonances

further possibilities arise for the behavior of the fermion Regge trajectories, one of which is suggested for the 1765-Mev resonance. (auth)

**28392** DISPERSION APPROACH TO TWO-BODY WEAK DECAYS. Masao Sugawara (Purdue Univ., Lafayette, Ind.). Phys. Rev., 135: B252-9(July 13, 1964).

A dispersion theoretic approach to two-body weak decays is discussed in which the masses of the particles are regarded as constants. In this approach, an analyticity assumption is introduced for the invariant decay amplitudes which are defined off the energy-momentum shell. These amplitudes are invariant functions of three invariant variables. The singularities and the dispersion relations for these amplitudes are very similar to those assumed by Mandelstam in the case of scattering. As examples, the pionic decays of hyperons and the leptonic decays of pions and kaons are discussed in detail in the first order with respect to the weak Hamiltonian. It is assumed that there exists a weak Hamiltonian which is localized in the sense of the present local field theory and can be treated as a small perturbation. In the case of the former example, it is shown that there are three kinds of pole terms corresponding to the above three invariant variables and that these pole terms are identical with those assumed in the pole approximation due to Feldman, Matthews, and Salam. The invariant decay amplitude in the case of the latter example becomes a constant, if the electromagnetic correction is ignored. This is to be contrasted with various dispersion relations proposed in the conventional approach in which the mass of the pion is regarded as the variable. The dispersion theoretic version of the usual V−A theory of the weak interaction is then constructed, in which the invariant decay amplitude (being a constant) is regarded essentially as the weak coupling constant. The experimental data concerning these leptonic decays indicate that the weak coupling constant defined this way is independent of not only whether the charged lepton is the electron or the meson($\mu$), but also whether the decaying particle is the pion or the kaon. (auth)

**28393** PIONIC DECAYS OF HYPERONS AND UNIVERSAL WEAK COUPLING. Masao Sugawara and Tetsuro Sakuma (Purdue Univ., Lafayette, Ind.). Phys. Rev., 135: B260-6(July 13, 1964).

The pionic decays of hyperons are analyzed in terms of the pole approximation of Feldman, Matthews, and Salam and the preceding paper. It is found that all the available experimental data are consistent with the universal weak coupling scheme, provided all the strong coupling constants have the same magnitude as the usual $\pi$-N coupling constant. In this universal weak coupling scheme, all the (dimensionless) weak coupling constants which appear in the residues of the pole terms have the same magnitude as the weak coupling constant determined in the preceding paper for the leptonic decays of pions and kaons. It is argued that this scheme is a dispersion theoretic version of the usual V−A theory of the weak interaction. The above universal coupling scheme predicts unambiguously that the s wave dominates in $\Sigma^+ \to n + \pi^+$ and the p wave dominates in $\Sigma^- \to n + \pi^-$, and also establishes some of the relative signs of the strong coupling constants. It is shown that there appears no other universal scheme of both the strong and the weak coupling constants. In particular, the above universal weak coupling scheme is not compatible with the usual unitary symmetry relations for the strong coupling constants, though this conclusion depends very sensitively on the mixing parameter in the unitary symmetry relations. The main consequences and a discussion of the above universal coupling scheme are given. (auth)

**28394** SELF-CONSISTENT CALCULATION OF THE $\rho$-MESON REGGE POLE. Myron Bander and Gordon L. Shaw (Stanford Univ., Calif.). Phys. Rev., 135: B267-71 (July 13, 1964). (TID-20434; ITP-110)

The left-hand discontinuities in the partial-wave amplitudes for $\pi$-$\pi$ scattering are assumed to be dominated by the exchange of the meson($\rho$) in a form suggested by the Regge representation for a resonance. This Regge behavior provides the necessary high-energy cutoff and allows the N/D equations to be solved. The partial-wave I = 1 amplitudes are calculated for noninteger angular momenta $l < 1$ as well as $l = 1$. The trajectory $\alpha_\rho(s)$ as well as the residue $\beta_\rho(s)$ of the meson ($\rho$) Regge pole are evaluated. An attempt is made to obtain a self-consistent solution for the relevant parameters, namely the position and width of the $\rho$ resonance and $\alpha_\rho(0)$. The results of this calculation give $\alpha_\rho(0) \gtrsim 0.9$. The I = 0 vacuum trajectory is also discussed. (auth)

**28395** CLASSICAL MOTIONS OF SPIN-$\frac{1}{2}$ PARTICLES. Kenneth Rafanelli and Ralph Schiller (Stevens Inst. of Tech., Hoboken, N. J.). Phys. Rev., 135: B279-81(July 13, 1964).

The classical trajectories and spin precessions originally postulated by Bargmann, Michel, and Telegdi for charged spin-$\frac{1}{2}$ particles are derived from the WKB solutions to the squared Dirac equation. Identical equations of motion are obtained from the WKB solutions to the Dirac equation. (auth)

**28396** MOTION OF A CHARGED PARTICLE IN A CONSTANT MAGNETIC FIELD AND A TRANSVERSE ELECTROMAGNETIC WAVE PROPAGATING ALONG THE FIELD. Charles S. Roberts and S. J. Buchsbaum (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev., 135: A381-9(July 20, 1964).

The relativistic equation of motion is examined for a charged particle in a constant magnetic field and a transverse electromagnetic wave propagating along the field. A general discussion is given of the effects at cyclotron resonance of the magnetic field of the wave and the relativistic mass increase with energy. An exact solution to the equation of motion is found for the case of a circularly polarized wave. The solution shows that when the index of refraction of the medium in which the wave propagates is not unity, the energy of the particle is a periodic function of time, the exact relationship being expressible in terms of elliptic integrals. When the index of refraction is unity, the effect of the magnetic field of the wave just compensates for the change in mass with energy, and the energy of the particle increases indefinitely at resonance. Several possible applications of this solution to classical cyclotron resonance phenomena are pointed out. As a numerical example, the case of an electron in a constant magnetic field of 1000 G initially at resonance with microwaves whose E field is 0.1 esu is considered. (auth)

**28397** PHOTOPRODUCTION OF $\pi$ MESONS BETWEEN 0.9 AND 4.0 Bev. R. Alvarez, Z. Bar-Yam, W. Kern, D. Luckey, L. S. Osborne, S. Tazzari, and R. Fessel (Massachusetts Inst. of Tech., Cambridge). Phys. Rev. Letters, 12: 707-10(June 22, 1964). (CONF-452-2)

The production of neutral and positive pions by photon reactions with protons is studied. Protons and gamma rays were measured in time coincidence at 60 to 90° in the center-of-mass system for the pion. Production cross

sections vs photon energies are presented for results obtained here and in previous experiments. (M.J.T.)

**28398** BROKEN SYMMETRIES AND MASSLESS PARTICLES. Walter Gilbert (Harvard Univ., Cambridge, Mass.). Phys. Rev. Letters, 12: 713-14(June 22, 1964).

The Goldstone theorem, that any solution of a Lorentz-invariant theory violating an internal symmetry operation of that theory contains a massless scalar particle, is discussed for relativistic and nonrelativistic theories. It is shown that the theorem fails trivially in the nonrelativistic case for reasons not affecting the validity of the relativistic version. (M.J.T.)

**28399** BROKEN SU(3) ⊗ SU(3) ⊗ SU(3) ⊗ SU(3) SYMMETRY OF STRONG INTERACTIONS. Peter G. O. Freund and Yoichiro Nambu (Univ. of Chicago). Phys. Rev. Letters, 12: 714-17(June 22, 1964).

A suggestion is made to consider, starting from the SU(3) symmetry, a hierarchy of symmetries which are even larger and at the same time more dramatically broken than the SU(3). The symmetry is enlarged up to SU(3) ⊗ SU(3) ⊗ SU(3) ⊗ $SU_3$), by using weak-interaction conserved vector currents combined with conserved axial vector currents and by dissociating the two indices of the baryon tensor octet representation. (M.J.T.)

**28400** WIDE-ANGLE PHOTOPRODUCTION OF MU PAIRS. J. K. de Pagter (Cambridge Electron Accelerator, Cambridge, Mass.), A. Boyarski, G. Glass, J. L. Friedman, H. W. Kendall, M. Gettner, J. F. Larrabee, and Roy Weinstein. Phys. Rev. Letters, 12: 739-42(June 29, 1964). (MIT-2098-41)

The photoproduction of muon pairs from carbon was studied using a 5-Bev bremsstrahlung beam. Initial results are reported, which when compared with theory provide a test of the validity of the quantum electrodynamic description of the muon propagator at squared four-momentum transfers up to about 8 $F^{-2}$. Cross sections were evaluated for all polar and azimuthal angle and energy combinations. Experimental values of the angular distribution of the muon-pair cross section are compared with theoretical calculations. (M.J.T.)

**28401** MEASUREMENTS AND CALCULATIONS OF NUCLEAR RADIATION DISTRIBUTIONS IN LIQUID HYDROGEN. W. A. Hehs and G. E. Miller (General Dynamics, Fort Worth, Tex.). Trans. Am. Nucl. Soc., 7: 66-7(June 1964).

**28402** THE BREMSSTRAHLUNG RADIATION FIELD OF A SCANNED MONOENERGETIC ELECTRON BEAM. Paul Farrell (Radiation Dynamics, Inc., Westbury, Long Island, N. Y.). Trans. Am. Nucl. Soc., 7: 202-3(June 1964).

**28403** "QUARK" PARTICLES AND UNITARY SYMMETRY. C. Noack (Universität, Heidelburg). Z. Physik, 179: 1-3(1964).

The possibility of including the triplet representation of $SU_3$ in the usual octet model without losing the integrity of charges is discussed. (auth)

**28404** PRODUCTION OF $\lambda(\Sigma^0)$-HYPERONS AND $K^0$-MESONS IN THE INTERACTIONS BETWEEN 7 Gev $\pi^-$-MESONS AND CARBON. V. A. Belyakov, A. V. Boyadzhiev, Yung-chang Wang, et al (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1586-97 (May 1964). (In Russian)

The production of $\Lambda(\Sigma^0)$ (or shortly, $\Lambda$)-hyperons and $K^0$-mesons by negative pions on carbon is investigated. The angular and momentum distributions of the particles are obtained, their production cross section is determined and the cross sections for various channels of the reactions are estimated. The fraction of strange particles produced in secondary processes was estimated. The $\Lambda$-hyperon momentum spectrum is compared with the $\pi p$-interaction spectrum. The experimental data are compared with calculations based on the cascade model and performed by the Monte-Carlo method. (auth)

**28405** A QUADRUPLET CLASSIFICATION OF PARTICLES. R. V. Smirnov (Leningrad State Pedagogical Inst., USSR). Zh. Eksperim. i Teor. Fiz., 46: 1637-40 (May 1964). (In Russian)

A classification of particles including zero mass particles, mesons, baryons, and resonances is proposed which is based on the properties of the solutions of an equation set which unites the Maxwell equations and equations for the two-component neutrino. In order to include mesons, baryons, and resonances in the classification, an isospin space is introduced about which it is assumed that its structure completely repeats the structure of spin space. A method for obtaining the set of quantum numbers corresponding to possible states of the particles is indicated. (auth)

**28406** COMPLEX ASYMPTOTIC EXPRESSIONS FOR INELASTIC PROCESS AMPLITUDES AND SINGULARITIES IN THE ANGULAR MOMENTUM PLANE. I. A. Verdiev, O. V. Kancheli, S. G. Matinyan, A. M. Popova, and K. A. Ter-Martirosyan (Inst. of Theoretical and Experimental Physics, Academy of Sciences, Georgian SSR and Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 46: 1700-14 (May 1964). (In Russian)

The total cross sections for production of n particles (or of n groups of particles with low energies in the c.m.s of each group) and the energy distribution of the particles in high energy inelastic collisions are calculated by the momentum integration technique. The values previously obtained for the most important cases of truly inelastic collisions and corresponding to the contribution of an isolated vacuum Regge pole are employed for asymptotic amplitude values. In order to avoid unnecessary complications it is assumed throughout that all particles are identical and do not possess spins or isospins. It is shown that for any inelastic process, certain momentum configurations of the produced particles exist whose contribution to the amplitude is the most significant. Distributions of the produced particles with respect to the logarithms of their momenta are found. The shape of these distributions significantly depends on the behavior of the vertex functions (corresponding to emission of particles or a group of particles by a region). It is shown that if the vertex functions do not decrease with decrease of the squares of the region momenta then there is a contradiction to the unitarity condition in the s channel for the amplitude of elastic scattering through a zero angle. The dependence of both parts of the unitarity condition in the s channel for the amplitude of elastic scattering through a nonzero angle on the magnitude of the transferred momentum $x^2$ is investigated. It is shown that the Regge asymptotic amplitude corresponding to the contribution of the vacuum pole is not expressed by the right part of the unitarity condition when all terms corresponding to the formation of any number of particles are taken into account. The dependence on $x^2$ can be reproduced only in case use is made of all the asymptotic values of all amplitudes (for elastic as well as inelastic scattering) corresponding to the contribution not of an isolated pole but of a whole set of singularities of the branching point

type in the j plane arranged at the right of the vacuum pole and condensing toward the point j = 1. (auth)

**28407** A GENERAL RELATION IN THE THEORY OF FERROMAGNETIC FERMI FLUIDS. I. E. Dzyaloshinskii (Inst. of Physics, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1722-5(May 1964). (In Russian)

It is shown that the total spin of a system of Fermi particles possessing a spectrum of the Fermi type (Fermi fluid) is equal to the sum of the excitation spins providing that only exchange forces are operative in the system. (auth)

**28408** WAVE EQUATION AND MAGNETIC MOMENT OF SPIN 2 PARTICLES. V. S. Tumanov (Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 46: 1755-60(May 1964). (In Russian)

A relativistic wave equation in matrix form is derived for particles with spin 2. A value of the proper magnetic moment of a spin-2 particle is obtained by going over to the nonrelativistic equation. The value obtained is consistent with the general hypothesis previously proposed by Belinfante. (auth)

**28409** ON POLARIZATION OF ELECTRONS IN AN INHOMOGENEOUS MAGNETIC FIELD. S. S. Sannikov. Zh. Eksperim. i Teor. Fiz., 46: 1761-3(May 1964). (In Russian)

The possibility of obtaining spiral (polarization directed along or opposite momentum) electrons by means of an inhomogeneous magnetic field is investigated theoretically. The correlation between the spin and momentum is calculated in the nonrelativistic limit. It is shown that electrons which move in an inhomogeneous magnetic field with a gradient along the lines of force acquire a certain longitudinal polarization. (auth)

**28410** THEORY OF BREMSSTRAHLUNG IN THE PRESENCE OF A MEDIUM. I. V. Andreev (Lebedev Inst. of Physics, Moscow). Zh. Eksperim. i Teor. Fiz., 46: 1764-7(May 1964). (In Russian)

Scattering and bremsstrahlung of a fast charged particle in a medium are considered. Scattering involving a definite radiation energy loss is calculated with double logarithmic accuracy. (auth)

**28411** QUANTUM PROCESSES IN THE FIELD OF A PLANE ELECTROMAGNETIC WAVE AND IN A CONSTANT FIELD. [PART] II. A. I. Nikishov and V. I. Ritus (Lebedev Inst. of Physics, Moscow). Zh. Eksperim. i Teor. Fiz., 46: 1768-81(May 1964). (In Russian)

The effects of the field of a plane electromagnetic wave on quantum processes occurring in the absence of the field are considered. The main features of such a process are analyzed for the particular case of the $\pi \to \mu + \nu$ decay. A general formula is derived for the probability of $\pi \to \mu + \nu$ decay in the field of the wave. The formula is investigated for various limiting cases defined by the magnitude of the parameters ea/m and ea/$\omega$ (a is the wave potential amplitude). For ea/m, ea/$\omega \ll 1$ the formula yields the corresponding probabilities of perturbation theory and for ea/m $\gg 1$ the probability $F(\chi)$, $\chi = e\sqrt{(F_{\mu\nu}P_\nu)^2}/m^3$ for the process in constant crossed field (EH = 0, E = H). If the proper conditions are fulfilled, $F(\chi)$ describes the process in an arbitrary constant field. A significant dependence of the probability on decay energy is demonstrated; for small values of $\chi$ the probability of $\pi \to \mu + \nu$ decay increases and the probability $\pi \to e + \nu$ decreases. With decreasing decay energy the sensitivity of the probability to the field strength increases. The exact expression for the probability removes the infrared divergence for photon absorption. In view of the importance of processes in crossed field a straightforward method of calculation is presented which is not connected with the limiting transition ea/m $\to \infty$. (auth)

**28412** GROUP PROPERTIES OF THE COMPLEX ANGULAR MOMENTUM. V. S. Popov and E. I. Dolinskii (Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 46: 1829-41(May 1964). (In Russian)

The group theoretical properties of the complex angular momentum are analyzed. The properties of the eigenfunctions $f_{\alpha m}(n)$ of the operator $L^2$ which correspond to the complex eigenvalues $\alpha(\alpha + 1)$ are discussed. The functions $f_{\alpha m}(n)$ possess nonintegrable singularities. A finite norm is set up for them which is invariant with respect to rotations. Matrices $D^{(\alpha)}_{mn}$ are determined which can be employed for transforming the functions $f_{\alpha m}(n)$ during finite rotations. It is shown that in a generalized sense these matrices form a representation of the rotation group. (auth)

**28413** WEAK INTERACTIONS AT HIGH ENERGIES. M. P. Rekalo (Inst. of Physics and Tech., Academy of Sciences, Ukrainian SSR). Zh. Eksperim. i Teor. Fiz., 46: 1891-6(May 1964). (In Russian)

Weak production of mesons due to the interaction between high energy neutrinos and nucleons is studied on the basis of an hypothesis regarding the singularities of the partial amplitude as a function of the angular momentum. An expression for the differential cross section and a set of isotopic relations depending on the isotopic spin of the leading pole are obtained. (auth)

**28414** EXCITATION OF CYCLOTRON OSCILLATIONS BY THE COLLISION OF TWO ELECTRON BEAMS. C. Etievant and M. Perulli (EURATOM-CEA, Fontenay-aux-Roses, France). p.209-18 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Evidence for a mechanism of instability in the vicinity of half the electron cyclotron frequency $\omega_{ce}/2$ was found in a system of two counter-streaming electron beams in a magnetic field in the absence of a static plasma. The symmetry of the system permitted the formation in the interaction chamber (73 cm long) of large amplitude electron cyclotron standing waves with a number of loops lying between 5 and 30, depending of the value of the magnetic field and the velocity of the beams (250 ev to 4000 ev). Measurements of frequency, wavelength, and growth time of the instability were made. This mechanism is obviously different from the classical double stream instability which can occur in the absence of a magnetic field. It corresponds to the unstable coupling of the slow space charge wave of one beam with the fast cyclotron wave of the other beam. In a finite cylindrical system this coupling is always possible because of the radial component of the oscillating electric field. (auth)

**28415** NUCLEON-NUCLEON SCATTERING AND THE MESON RESONANCES. Paul Berl Kantor. Thesis, Princeton, N. J., Princeton Univ., 1963. 178p.

Nucleon-nucleon partial wave scattering amplitudes ${}^{I}_{L}f^{J}_{L'}(p^2)$ were studied in the elastic region, assuming the Mandelstam analyticity, by a scheme that approximates the two pion exchange contribution by poles corresponding to the $\rho$ and $f_0$ resonances and multi-pion exchange by poles corresponding to the $\eta$ and $\omega$ resonances. It is shown that the usual assumptions of an N/D calculation, which state that f in the physical region is determined by the value of the driving terms Im $_{B}f$, in the unphysical region, imply also

that ${}_Bf(p^2) = \mathrm{Re}f(p^2) - (p/\pi)\int_0^\infty [\mathrm{Im}\, f(p^{2'})dp^{2'}/(p^{2'} - p^2)]$ can be written. The true amplitude here is f and ${}_Bf$ is the function whose discontinuity in the unphysical region is the usual input data for an N/D calculation. The indicated integral is approximated by assuming maximal inelasticity at high energy and using the experimentally determined amplitude at low energies. Using the indicated dynamical assumptions ${}_Bf$ can be expressed as a linear combination where the G's are known functions and the $g(\alpha)$ are quadratic functions of the strengths of the nucleon-resonance vertices. They are not all independent. The functions h were explicitly computed for the singlet partial waves ${}^1f^{IO}_J$, J = 0, . . . , 4, using the YLAM, YLAN3M phase shifts and the corresponding functions G were determined for the indicated resonances. The advantages of the present procedure are: the two and the multi-pion contributions are treated in a simple but reasonable approximation; the requirements of unitarity are automatically satisfied by a given equation and, by using known phase shifts the integral equations of the N/D method, with their associated ambiguities and divergences, are avoided. The ultimate objective is the determination of coupling constants consistent with the experimental data. The method used reduces this to a standard regression analysis. A criterion of acceptability was established for coupling constants based on the $\chi^2$ test, and shows that the present dynamical model is not obviously invalid. Finally, a few possible starting points for the regression analysis search procedure and an iterative technique that may be useful in that search is suggested. (Dissertation Abstr., 24: No. 11, 1964)

**28416** OVERLAPPING FINAL STATE RESONANCES. John Brayton Bronzan. Thesis, Princeton, N. J., Princeton Univ., 1963. 95p.

The effect of rescattering of particles in three body final states was studied for the case in which two pairs rescatter resonantly. The transition amplitude to the final state is conjectured to satisfy the Khuri-Treiman dispersion representation. The resulting dynamical equation is a linear singular integral equation. Considerable care is required to fix the physical branch of the kernel of the dynamical equation. After it is defined the equation is not solved, but an approximation scheme is developed that should yield a good approximation to the transition amplitude for narrow rescattering resonances. In this approximation it was found that the final state of two nucleons and a pion has the mass configuration required for a small satellite resonance to the N* to occur near the low energy corner of the Dalitz plot. This satellite moves with energy, and disappears off the low energy edge of the plot for total invariant energies of the system above 2.6 Bev. A rough calculation shows that the satellite is probably large enough to be seen using available experimental techniques. It should appear in $N + N \rightarrow N + N + \pi$. (Dissertation Abstr., 24: No. 11, 1964)

**28417** NEUTRAL DECAY MODES OF THE H MESON. Michael Wood Peters. Thesis. Madison, Wis., Univ. of Wisconsin, 1964. 66p.

The neutral decay modes of the $\eta^0$ were investigated in a liquid hydrogen bubble chamber. The decay modes $\eta^0 \rightarrow \gamma + \gamma$ and $\eta^0 \rightarrow \pi^0 + \pi^0 + \pi^0$ are identified by observation of electron pairs produced by the decay photons. Detection probabilities for each of the decay modes are calculated by Monte Carlo methods. Likelihood contours are computed for the two parameters $\alpha = \Gamma_\eta(2\gamma)/\Gamma_\eta(\text{charged})$, $\beta = \Gamma_\eta(3\pi^0)/\Gamma_\eta(\text{charged})$, with normalization to the charged decays observed by other experimenters in the same film. The maximum likelihood results, with estimated standard deviations, are $\alpha = 1.05 \pm 0.45$ and $\beta = 0.55 \pm 0.23$. Comparisons with other experiments and with theoretical calculations are presented. (Dissertation Abstr., 24: No. 11, 1964)

**28418** TWO-PION-EXCHANGE CONTRIBUTION TO THE LAMBDA-NUCLEON INTERACTION. Rudolph Schrils. Thesis, Boulder, Colo., Univ. of Colorado, 1963. 96p.

The two-pion-exchange contribution to the lambda-nucleon scattering matrix was calculated with the Dyson S-Matrix formalism under the assumption of even sigma-lambda parity and a universal pion-baryon interaction. The coefficients of the scattering matrix in spin space were obtained through fourth order in the pion-baryon coupling constants. This calculation leads to a two-pion-exchange contribution to the zero-energy lambda-nucleon scattering amplitude, which is spin independent. This conclusion was compared with the results of calculations of lambda-nucleon scattering amplitudes in terms of second- and fourth-order Tamm-Dancoff potentials by means of coupled Schrödinger equations describing the lambda-nucleon and sigma-nucleon systems. The results obtained suggest the use of a semi-phenomenological lambda-nucleon potential, which for large separations and for low energies, is predominantly spin-independent. For scattering a finite energy, the scattering matrix is spin dependent and contains a term that is anti-symmetric in the spins of the fermions; such a term does not appear in the charge-symmetric nucleon scattering matrix. The consequences of such a term, such as its effect on the difference in polarizations of the scattering experiment, were examined in some detail. The importance of this term is estimated in a numerical evaluation of its coefficient in the low-energy approximation. (Dissertation Abstr., 24: No. 11, 1964)

**28419** COLLISION THEORY. Marvin L. Goldberger and Kenneth M. Watson. Structure of Matter Series. New York, John Wiley & Sons, Inc., 1964. 926p. $19.95.

A systematic description of the basic principles of collision theory is given. The mathematical formulation of the quantum theory of scattering is presented by constructing wave packets for projectile and target and following the time development of the system. The two-body problem with central forces, scattering by noncentral forces, the lifetime and decay of virtual states, an introduction to dispersion theory, and scattering by systems of bound particles are treated. (M.J.T.)

**28420** PROCEEDINGS OF THE INTERNATIONAL SCHOOL OF PHYSICS "ENRICO FERMI." COURSE XXVI. SELECTED TOPICS ON ELEMENTARY PARTICLE PHYSICS. VARENNA ON LAKE COMO. VILLA MONASTERO. JULY 23-AUGUST 4, 1962. M. Conversi, ed. New York, Academic Press, 1963. 303p. $10.00.

Nine papers are included. Separate abstracts were prepared for 6. Three papers were previously abstracted for NSA; see abstracts 17: 11478, 11496, and 29502. (M.J.T.)

*For abstracts of individual papers see: 28198, 28421, 28422, 28423, 28424, and 28425.*

**28421** FORM FACTORS OF ELEMENTARY PARTICLES. S. D. Drell (Stanford Unif., Calif.). p.184-240 of "Selected Topics on Elementary Particle Physics." New York, Academic Press, 1963.

Calculation of the electron-proton scattering cross section is outlined, considering Dirac theory, the Feynman propagator, and the S matrix. The general form of electron-proton scattering is obtained, and corrections to the Rosenbluth form are discussed. Form factors are defined

and interpreted, and their correlation with other processes in pion-nucleon physics is discussed. The dispersion theory approach to calculations of nucleon form factors is described. Vector resonances and calculation of absorptive amplitudes are considered. The question of the validity of quantum electrodynamics in form-factor derivations is examined. Electromagnetic structure of neutral particles, conserved currents, and form factors in weak interactions are discussed. (M.J.T.)

**28422** PREDICTION OF PION PHASES BY DISPERSION RELATIONS. D. Atkinson (Univ. of London). p.241-7 of "Selected Topics on Elementary Particle Physics." New York, Academic Press, 1963.

A theoretical method of deriving information about the scattering process $\pi + \pi \rightarrow \pi + \pi$ from the experimental knowledge of the process $\pi + n \rightarrow \pi + n$ is developed. The technique depends on exploiting the analyticity, crossing, and unitarity of the scattering matrix. S, P, and D wave $\pi\pi \rightarrow \pi\pi$ phase shifts can be deduced. (M.J.T.)

**28423** DETERMINATION OF THE $\mu$-NEUTRINO HELICITY. P. Franzini (Università, Pisa, Italy and Istituto Nazionale di Fisica Nucleare, Pisa, Italy). p.248-53 of "Selected Topics on Elementary Particle Physics." New York, Academic Press, 1963.

An experiment was performed to measure the sign of the helicity of negative muons produced in the decay of negative pions. The result, that helicity of negative muons is positive, agrees with other experiments and with the predictions of the V-A theory. Thus, the $\mu$ neutino has the same helicity as the neutrino involved in $\beta$ decay, and no information is obtained on the question of the identity of the two neutrinos. Agreement between expected and measured muon yield and asymmetry proves that the muon is a Dirac particle having only electromagnetic interaction. (M.J.T.)

**28424** STRANGE-PARTICLE DECAYS. F. S. Crawford, Jr. (Univ. of California, Berkeley). p.88-148 of "Selected Topics on Elementary Particle Physics." New York, Academic Press, 1963.

Weak decays of strange particles are discussed. Evidence concerning the $\Delta I = 1/2$ rule in nonleptonic decays and the $\Delta I = 1/2$ and $\Delta S = \Delta Q$ rules in leptonic decays is surveyed. The decays $\Lambda \rightarrow N + \pi$, $\Sigma \rightarrow N + \pi$, $\Xi \rightarrow \Lambda + \pi$, $K \rightarrow 2\pi$, $K \rightarrow 3\pi$, and $K \rightarrow \pi + L + \nu$ (L = e or $\mu$) are considered. Examples illustrating invariance with respect to quantum numbers are given. The definition and measurement of hyperon decay parameters are reviewed. (M.J.T.)

**28425** STRANGE-PARTICLE RESONANCES. H. K. Ticho (Univ. of California, Los Angeles). p.149-83 of "Selected Topics on Elementary Particle Physics." New York, Academic Press, 1963.

The present state of experimental evidence concerning strange particle resonances is described. Only resonances for which there is very strong evidence—the $K^*_{\frac{1}{2}}$ (890), $Y^*_1$ (1385), $Y^*_0$ (1405), $Y^{**}_0$ (1520), and $\Xi^*_{\frac{1}{2}}$ (1530)—are considered. Modes of production and decay, mass, width, and quantum numbers are discussed for each. (M.J.T.)

**28426** TRANSVERSE MOMENTUM OF SECONDARY PARTICLES PRODUCED IN HIGH ENERGY NUCLEAR INTERACTIONS. P. L. Jain, H. C. Glahe, J. D. Rinaldo, and P. D. Bharadwaj (State Univ. of New York, Buffalo). 13p. (CONF-531-2)

From American Physical Society, 1964 Southwestern Meeting, Tucson, Ariz., Feb. 1964.

The spectra of the transverse momentum of mesons($\pi$), mesons(K), protons, and hyperons($\Sigma$) produced by 6.3-Bev protons, 16.3-Bev/c meson($\pi$), and 28-Bev/c protons in nuclear emulsion are presented. The shapes of the spectra seem to be independent of the type of the particle produced in an interaction. The average transverse momentum values for heavy particles are slightly greater than those of light particles. The results are compared to previous experimental work and the predictions of the theories of Fermi, and Heisenberg and Landau. (auth)

**28427** ON THE THEORY OF UNSTABLE PARTICLES. E. Boldt (Rutgers Univ., New Brunswick, N. J.) and G. Sandri. 9p. (CONF-481-61)

From American Physical Society Annual Meeting, New York, Jan. 1964.

A new method in the theory of unstable particles is introduced. It is applied to a simple model to show how the exponential regime of the decay can be isolated systematically. It is further shown that the method prescribes the precise conditions to which the initial wave function must be submitted for this exponential decay to ensue. The prescription of these conditions constitutes in fact a definition of an "unstable particle" in quantum theory. (auth)

## Field Theory and Quantum Mechanics

*Refer also to abstracts 28361 and 28411.*

**28428** (ANL-Trans-27) FOCK EQUATIONS IN MULTICONFIGURATIONAL APPROXIMATION. A. P. Yutsis. Translated by Elmar K. Wilip (Argonne National Lab., Ill.), from Zh. Eksperim. i Teor. Fiz., 23: 129-39(1952). 14p.

The method of the multiconfigurational approximation is discussed. Fock's method was used for the determination of single-electron wave functions in this approximation. The results yield Fock equations in multiconfigurational approximation. A study of these equations showed, that in some cases the use of multiconfigurational wave functions can lead to a certain variation of the correction values for the energy in comparison to their values determined by means of monoconfigurational single-electron wave functions. (auth)

**28429** ON THE STRUCTURE OF THE SOURCE SYSTEM OF ELECTRIC AND MAGNETIC MULTIPOLE RADIATION. A. Rubinowicz. Acta Phys. Polon., 25: 453-72 (Mar. 1964). (In German)

Some relations were derived on the basis of which a plain image of the source system of electric or magnetic multipole radiation can be made. They connect two kinds of electromagnetic multipoles. One of the multipoles, as usual, is defined by the Debye potential, which includes the associated spherical harmonics in a definite order. The source system of the other multipole was obtained by proceeding from electric or magnetic dipoles according to the Maxwell method by means of a continued parallel comparison of two similar source systems, which have opposite signs of charge at the corresponding poles. (tr-auth)

**28430** ON THE QUESTION OF DIVERGENCE-FREE SERIES DEVELOPMENT OF THE S-MATRIX IN QUANTUM ELECTRODYNAMICS. Manfred Hoffmann (Universität, Leipzig). Acta Phys. Polon., 25: 473-84(Mar. 1964). (In German)

By the use of suitable conditions such as asymptotic conditions, according to a concept of Hall for the treatment of scattering problems, no ultraviolet divergence should ap-

pear in the development segments of the S-matrix according to powers of the coupling constants. The treatment of the scattering of a bare photon on a physical electron showed that in consequent accomplishments new basic concepts appear in spite of fourth-order ultraviolet divergence. In higher approximations only real divergence is to be expected. (tr-auth)

**28431** THE PHYSICAL MEANING OF A NON-UNITARY TRANSFORMATION CONNECTING THE DIRAC AND PAULI FORMALISMS. W. Hanus (N. Copernicus Univ., Torun, Poland). Bull. Acad. Polon. Sci., Ser. Sci. Math. Astron. Phys., 12: 109-12(1964).

The methods of a correct reduction of the Dirac electron theory to the non-relativistic approximation are discussed, and a physical interpretation of the non-unitary transformation involved is presented. (C.E.S.)

**28432** RESONANCES IN THE SMITH-PURCELL EFFECT. A. Hessel (Polytechnic Inst. of Brooklyn, Farmingdale, N. J.). Can. J. Phys., 42: 1195-1211(June 1964).

A rigorous solution is derived for the problem of radiation of the Smith-Purcell type from bunched electric-current sheath above a plane exhibiting a periodically varying surface reactance. The plane is regarded as a model of an optical reflection grating. The solution indicates that the presence of the grating will give rise to electromagnetic resonance effects which are closely related to the so-called Wood anomalies encountered in optical-grating spectroscopy. Utilization of these resonances may be advantageous in the generation of millimeter waves. (auth)

**28433** LIGHT PROPAGATION IN A HOMOGENEOUS MAGNETIC FIELD. R. Kaitna and P. Urban (Universität, Graz). Nucl. Phys., 56: 518-28(Aug. 1964).

Green's function for the Dirac equation in the presence of a homogeneous magnetic field of infinite extension is calculated without the usual integral representations. Thus it is possible to give a good theoretical approach to the effect of the variation of the velocity of high-energy photons in the presence of very intensive magnetic fields. In addition the index of refraction of such a field is computed. The results are discussed with regard to possible experimental tests. (auth)

**28434** UNIFIED FIELD THEORY. F. I. Mikhail (A'in Shams Univ., Faculty of Science, Cairo). Nuovo Cimento (10), 32: 886-94(May 16, 1964).

A unified field theory is formulated using a tetrad vector field. The field relations are derived by following a procedure similar to that used by Einsten in 1951, the affine connection being defined in terms of the tetrad field instead of Einstein's nonsymmetric tensor $g_{\mu\nu}$. The suggested field relations are applied to the spherically symmetric tetrad field used by Einstein in 1930. The solution obtained is shown to correspond to a purely gravitational field. The Riemannian space associated with the tetrad field obtained is transformed to the ordinary Schwarzschild's space-time. (auth)

**28435** ON STATIONARY SYSTEMS WITH SPHERICAL SYMMETRY. R. M. Misra (Univ. of Gorakhpur, India). Nuovo Cimento (10), 32: 939-42(May 16, 1964).

It was found that the equations of the gravitational field of a large number of gravitating particles of equal masses with spherical symmetry were not given correctly by Einstein. The correct form of these equations is obtained here. However, the conclusions arrived at by Einstein remain unaltered. (auth)

**28436** GLOBAL MASTER EQUATION. [PART] I. G. Sandri (Aeronautical Research Associates of Princeton, Inc., N. J.). Nuovo Cimento (10), 32: 985-90(May 16, 1964).

A new master equation is derived very directly from the Liouville equation. The validity of the new equation does not depend on the details of the two-body potential and constitutes therefore a considerable generalization of the known results. (auth)

**28437** ON LOCAL QUANTUM FIELD THEORY WITHOUT ULTRAVIOLET DIVERGENCES. THIRD ORDER. G. V. Efimov (CERN, Geneva). Nuovo Cimento (10), 32: 1046-58(May 16, 1964).

It was shown in the nonlinear local quantum theory of the scalar one-component field that the difficulties of the local theory associated with the presence of the ultraviolet divergences can be removed in second-order perturbation theory by the introduction of an interaction Lagrangian satisfying certain requirements. The third order of perturbation theory is investigated, and it is shown that no new restrictions appear on the interaction Lagrangian. Unitarity is fulfilled for the Green's function in this order. (auth)

**28438** SEARCH FOR EXTRA-DIMENSIONAL EFFECTS. C. Gregory (Univ. of Hawaii, Honolulu). Nuovo Cimento (10), 32: 1985-91(May 16, 1964).

A model which conjectures the existence of an additional spatial dimension is investigated. A categorization of the spatio-temporal variables is suggested by observing that the ordinary variables of three-space are controllable while the temporal variable is not, due to the inexorable passage of time. To the additional spatial dimension is imputed the uncontrollable label on the grounds that the associated numbers are not subject to prediction. Assuming relativity theory is valid in the enlarged space, the Doppler effect technique is extended to enable a description of the effects of motion in an additional direction. Some measurements obtained by the Mössbauer effect analyzed statistically in the light of the above proposals. It is found that the fluctuation in the data may be ascribed to the independent random motions of absorber and detector in the additional direction about a rest position, both with r.m.s. velocity 12.2 m/sec. (auth)

**28439** ABSORBED HELIUM AS A QUANTUM FLUID. D. D. Betts (Univ. of London), F. D. Manchester, and E. J. Woods. Phys. Letters, 10: 59-61(May 15, 1964).

The possibility that adsorbed helium is a quantum fluid even at low partial pressures is considered. It is proposed that the system of $^3$He atoms adsorbed in a zeolite crystal is analogous to the case of electrons in a metal. The effective $^3$He–$^3$He interaction is discussed. (C.E.S.)

**28440** A SIMPLE GAUGE-INVARIANT METHOD IN THE THEORY OF INTERACTING BOSON SYSTEMS. Cs. Hargitai (Central Research Inst. of Physics, Budapest). Phys. Letters, 10: 65-7(May 15, 1964).

A system of spinless bosons interacting via two-body forces is discussed. A method based on the equations of motion and on the equal-time commutation rules of the field operators is used. Exact integral relations between the spectral functions of various one-particle correlation functions are derived. To obtain the ground-state energy and the spectrum of low-lying one-particle excitations from these relations an approximation needs to be made only in the last step. (C.E.S.)

**28441** ON THE STATISTICAL DERIVATION OF MAXWELL'S EQUATIONS FOR A SYSTEM OF CHARGED POINT PARTICLES. S. R. de Groot (Institute of Theoretical Physics, Amsterdam) and J. Vlieger. Phys. Letters, 10: 71-2(May 15, 1964).

Maxwell's equations are derived for a system of charged point particles by means of distribution functions that depend on higher time derivatives of the particle positions and take into account the retarded character of the fields. (C.E.S.)

**28442** APPLICABILITY OF THE SCHRÖDINGER PERTURBATION THEORY TO BOUND STATES. K. Hausmann, W. Macke, and P. Ziesche (Technische Universität, Dresden). Phys. Letters, 10: 73(May 15, 1964).

It is shown that it is possible to calculate bound states by perturbation theory from free particle states of the analytic behavior of the function $E(\lambda)$ in the neighborhood of $\lambda = 0$ is carefully analyzed (E is ground state energy, $\lambda$ is a coupling constant). (D.E.B.)

**28443** SINGULAR POTENTIALS WITH SHORT RANGE. H. Cornille (CERN, Geneva) and E. Predazzi. Phys. Letters, 10: 149-51(May 15, 1964).

The difficulties connected with unrenormalizable field theoretical interactions are discussed. These difficulties seem to be similar to those encountered in the quantum theory of repulsive singular potentials. A class of interactions is considered with terms having a more pathological behavior near the origin. Preliminary results and essential features of the method are presented. (C.E.S.)

**28444** METHOD OF THE SELF-CONSISTENT FIELD IN GENERAL RELATIVITY AND ITS APPLICATION TO THE GRAVITATIONAL GEON. Dieter R. Brill (Yale Univ., New Haven) and James B. Hartle. Phys. Rev., 135: B271-8(July 13, 1964).

Concentrations of radiation held together for a long time by their own gravitational attraction ("geons") have been studied for nearly a decade. The previous analyses are extended to the case where gravitational waves are the source of the geon's mass energy. To analyze these solutions of the free-space Einstein equations with persistent features, an approximation method is developed to treat small ripples on a strongly curved background metric. The background metric describes the large-scale persistent features of the geon and is taken to be spherically symmetric. The waves superimposed on this background have an amplitude small enough so that their dynamics can be analyzed in the linear approximation; however, their wavelength is so short and their time dependence so rapid that their energy is appreciable and produces the strongly curved background metric in which they move. The Einstein equations are investigated in this limit of short wavelength. It is found that the large-scale features of thin-shell spherical gravitational geons — in fact, of thin-shell spherical geons constructed from any field of zero rest mass — are identical to those of the spherical electromagnetic geons analyzed previously. (auth)

**28445** CLASSICALLY RADIATIONLESS MOTIONS AND POSSIBLE IMPLICATIONS FOR QUANTUM THEORY. G. H. Goedecke (New Mexico State Univ., University Park). Phys. Rev., 135: B-281-8(July 13, 1964).

A simple general criterion is developed, using the retarded potentials of classical electromagnetic theory, for absence of radiation from arbitrary time-periodic charge-current distributions. The criterion is applied to rigid, finitely-extended distributions of charge which may undergo orbital motion with period T. It is found that, for this type of distribution, the condition for no radiation is that the extent b of the distribution be an integer multiple of cT. Some of these distributions may spin while orbiting. There exists at least one asymmetric spinning distribution which doesn't radiate under this condition; for this distribution, the (constant) spin angular velocity must be proportional to an integer $\geq 0$ times c/b. This leads to the result that part of the total (electromagnetic) angular momentum which is associated with the spin angular velocity must be an integer $\geq 0$ times $e^2/c$ times a numerical constant the value of which depends on the details of the distribution. It is shown that, when such nonradiating distributions are considered as stable particles, there exists an intrinsic uncertainty relation of the same form and with almost the same meaning as that of quantum theory. (auth)

**28446** THEORY OF RADIATIVE CORRECTIONS FOR NON-ABELIAN GAUGE FIELDS. Bryce S. DeWitt (Princeton Univ., N. J. and Inst. for Advanced Study, Princeton, N. J.). Phys. Rev. Letters, 12: 742-6(June 29, 1964).

Feynman investigated the problems arising in an attempt to quantize a field possessing a non-Abelian infinite-dimensional invariance group. It was found that radiative corrections for such a field could be calculated in perturbation theory in lowest order while simultaneously carrying out a consistent renormalization scheme, maintaining manifest covariance, and securing unitarity of the S matrix. In dealing with higher order radiative corrections, the previous technique of Feynman is less successful in formulating a consistent set of calculational rules. It is indicated how a slightly different approach, introducing a background field satisfying the classical dynamical equations, overcomes these difficulties. (M.J.T.)

**28447** ON A CONVERGENT MODEL OF QUANTUM ELECTRODYNAMICS. [PART] II. H. A. Ferwerda (Rijksuniversiteit, Groningen, Netherlands). Physica, 30: 665-701(Apr. 1964).

The regularized model introduced previously is applied to the third order vertex diagram and gives a convergent expression. It is proved that this model is renormalizable and expressions are derived for the radiative corrections. A short discussion is given of the infrared divergence problem which is shown to be the same as in conventional theory. The special choice of the transverse (Landau) gauge for the photon propagator, which is used throughout this model, is more closely discussed. It is checked that the Feynman-Dyson and Landau gauges give the same results in the conventional theory, which is obtained from this model if the regularizing parameter(s) tends to zero. It could not be proved that the Feynman-Dyson and Landau gauges give identical results in the case of the regularized model. So it seems as if the choice of the transverse gauge is an additional working hypothesis of this model. The computational techniques of the model which differ considerably from those in conventional theory are given. (auth)

**28448** MACROSCOPIC TIME EVOLUTION AND INHOMOGENEOUS MASTER EQUATION. MACROSCOPIC DESCRIPTION OF QUANTUM GASES. [PART] II. Siegfried Grossmann (Technische Hochschule, Munich). Physica, 30: 779-807(Apr. 1964).

Macroscopic changes of the properties of quantum gases need microscopic finite time intervals, so that not the microscopic infinitesimal equations of motion itself but rather their time integrated form lead to macroscopic-stochastical or macroscopic-deterministical equations. Results concerning the macroscopic unitary time operators for streaming and collisions in dilute quantum gases with

short range forces at room temperature are reported. They are obtained by a generalization of Heitler's theory of radiation to the many-body problem. As an application an inhomogeneous master equation is derived, which shows a spatial streaming part besides the wellknown collisional term. (auth)

**28449** PARTIAL SELF-ENERGY PARTS OF KADANOFF-BAYM. S. Fujita (Université Libre, Brussles). Physica, 30: 848-56(Apr. 1964).

The fundamental equations of Kadanoff and Baym (K-B) relating Green's functions (g> and g<) and self-energy parts (Σ> and Σ<) are derived directly without going through the technique of imaginary-time Green's function. Explicit definitions for Σ> and Σ< are given in terms of diagrams. The derivation based on the perturbation theory suggests the possible use of Green's function defined with a more general density operator than the equilibrium one e.g. for the problem of approach to equilibrium. The method of K-B is compared with the existing theories of irreversible processes developed by others. The method agrees in principle with the perturbation method of Fujita. The self-energy parts (Σ<,Σ>) are related to $(W_W G_U)$ of Van Hove and $\phi(z)$ of Prigogine-Résibois both responsible for localized collision processes but they contain also the information about the previous history of particles depending on a given initial condition. The separation of these apparently different processes is however one of the main points in the theories of Van Hove and Prigogine-Résibois. (auth)

**28450** SYNCHROTRON RADIATION OF CHARGED PARTICLES IN A DIPOLE MAGNETIC FIELD. [PART] I. A. A. Korchak (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Academy of Sciences, USSR). Soviet Astron. AJ (English Transl.), 7: 764-71(May-June 1964).

The Stokes parameters characterizing synchrotron radiation in a dipole magnetic field are computed for a special electron distribution function: an exponential energy spectrum $E^{-\gamma}$, a $\sin^n\alpha$ angular distribution, and a Gaussian density distribution in the equatorial plane. The magnetic dipole moment is taken perpendicular to the line of sight for simplicity. Then the spectral radiation density $I_\nu$, the polarization $\rho$, and the position angle $\chi$ depend on the exponent $\gamma$ of the energy spectrum and the parameter $\underline{n}$ in the angular distribution. The method for evaluating the latter quantities and the total electron energy from known empirical values of $I_\nu$, $\rho$, and $\chi$ is illustrated using the radio emission from Jupiter's radiation belt as an example. (auth)

**28451** THE PRINCIPLE OF CORRESPONDENCE IN THE GENERAL THEORY OF RELATIVITY. H. Keres (Inst. of Physics and Astronomy, Academy of Sciences, Estonian SSR). Zh. Eksperim. i Teor. Fiz., 46: 1741-54 (May 1964). (In Russian)

In Newtonian theory the gravitational field may be described, in terms of the suitably chosen coordinate system, by means of the coefficients of the line element of the three-dimensional Euclidean space. This permits one to compare directly the relativistic theory of gravitation with Newtonian theory. A limiting process in which the gravitational fields of the general theory of relativity tend toward the corresponding fields of Newtonian theory is described. A correspondence of quantities of the general theory of relativity with quantities of Newtonian theory is established. The Newtonian limit of the gravitational field of the second type (according to Petrov's classification) admitting a group of motions of maximum order $G_6$ is computed. (auth)

**28452** SOME PROBLEMS IN QUANTUM FIELD THEORY: COUPLED RESONANCES AND ANGULAR MOMENTUM OF BREMSSTRAHLUNG. Ghazi Qasim Hassoun. Thesis, Minneapolis, Univ. of Minnesota, 1963. 91p.

I. The problem of two unstable systems, each having a given decay mode that are coupled to each other, is considered. A model, which is exactly soluble, is given to describe the two coupled systems. The model is a generalization of the Lee Model describing an unstable particle. The effect of the coupling on the masses and resonance widths of the two systems is studied. It was found that the effect of the coupling on the masses is such as to separate their magnitudes farther apart. The effect of the coupling on the resonance widths is to bring them closer together. The decay spectra of the two coupled systems are calculated and an approximate expression for the branching ratio of the two given decay modes for each system is obtained. The results are applied to the $\rho^0 - \omega$ and $Y_1^{*0} - Y_0^*$ electromagnetically coupled pairs. Generalization of the two coupled resonances model is then briefly discussed. II. It was previously pointed out that the statistical independence of photon emission in the infrared limit in a bremsstrahlung scattering process may lead to a logarithmically divergent angular momentum for the radiated photons and scattering system. It is shown that the expectation value of the electromagnetic angular momentum vector and that of the total system in the scattered state are finite, the fomer being zero; but that the expectation values of the square of the respective angular momenta are infrared divergent. Qualitatively, this means that an incident particle at a large impact parameter can scatter from a potential. This may be ascribed to the structure of the physical particle, that is, to its photon cloud. Intuitively, the occurrence of a large angular momentum may be seen by noting that the scattering cross section for a process with the emission of a given number of unobserved photons is sharply peaked. Similar results were obtained for a scalar field of vanishing mass replacing the electromagnetic one, which emphasizes that the divergence is not caused by the radiated photons' spin. (Dissertation Abstr., 24: No. 11, 1964)

**28453** COULOMB GREEN'S FUNCTIONS. Levere Cortez Hostler. Thesis, Stanford, Calif., Stanford Univ., 1964. 318p.

The Coulomb Green's function for the nonrelativistic Schrödinger equation is obtained in closed form. The partial wave expansion is summed using an integral representation for a product of two Whittaker functions with different arguments. The Neumann's series for $J_\nu(k_t)$ is required in evaluating the sum on states. There results an integral representation expressing the nonrelativistic Coulomb Green's function as an integral involving a Bessel function. The final expression obtained for the Green's function is given. The Coulomb Green's functions for the Klein-Gordon and iterated Dirac equations are obtained in closed form in the Furry approximation, $a^2/(J + \frac{1}{2})^2 \ll 1$, $a = ze^2/4\pi\hbar c$. The derivation of the Eigenfunction expansions here poses a special problem due to the fact that dealings are being made with wave equations that are second order in the time derivative rather than only first order. The Klein-Gordon Green's function in the Furry approximation is shown to be at the same time the exact Green's function for the Klein-Gordon equation without the potential squared term. An alternate and very simple derivation of the approximate Green's function of the iterated Dirac equation is given

using perturbation theory. From this approximate Green's function an approximate Coulomb Green's function in closed form for the Dirac equation itself is constructed. The relativistic and nonrelativistic Coulomb wave functions with modified plane wave behavior at large distances are studied using the preceding methods and results. (Dissertation Abstr., 24: No. 11, 1964)

**28454** THE CALCULATION OF TRANSPORT PROPERTIES OF A QUANTUM SYSTEM. William Warren Longley, Jr. Thesis, Boulder, Colo., Univ. of Colorado, 1963. 111p.

The problem of developing transport coefficients of a quantum system from the basic equations of motion was investigated. The basic Kubo formalism for developing linear transport coefficients was extended to include bulk viscosity and thermal conductivity. The derivations of these two coefficients are new; however, the results are known from other work. The bulk viscosity derivation depends on a transformation of position and momentum operators, which is identified with a change of the volume of the system; the thermal conductivity derivation depends on a position dependent transformation of single-particle energies, which is identified with a temperature gradient. The thermal conductivity of a simple model was evaluated by perturbation-expansion techniques. The four lowest orders in the perturbation series were calculated under the assumption that the autocorrelation expression vanishes after a sufficient period of time. A relaxation time was found that can be written as a power series starting with the inverse second power of the coupling constant. Additional terms that indicate a memory effect are also present, starting with the zero order term. The possibility of using the resolvent formalism for the calculation of transport coefficients from Kubo-type expressions was also investigated. The transport coefficients can be expressed easily in terms of the density matrix, the solutions of the generalized master equations, and the operators for the dynamic fluxes. (Dissertation Abstr., 24: No. 11, 1964)

**28455** EXPLICIT REPRESENTATION OF DISCRETE-SYMMETRY TRANSFORMATIONS IN THE QUANTUM THEORY OF FREE FIELDS. Kishin Hariram Mariwalla. Thesis, Athens, Ga., Univ. of Georgia, 1963. 101p.

Studies were made on the role of the discrete symmetries of space inversion, time reversal, particle conjugation, and their combinations from the point of view of their representations. For this purpose, after a brief introduction to the physical ideas underlying the discrete symmetries, the formalism of quantum theory of free fields is summarized. The explicit representations of the discrete symmetry transformations are then constructed within the scope of this formalism. The explicit forms of the representations constructed are not in terms of the field operators themselves, but rather their Fourier transforms. The fields treated are: the Hermitian and non-Hermitian Klein-Gordon fields, the electromagnetic field, and the Dirac field. The representations are given in different forms, and a possible physical interpretation of the generators of the discrete symmetry transformation is investigated. The results show that there exists a prescription for writing down a representation in the form of unitary factors. In this form the generators of each of the unitary factors can be connected with the relevant physical quantities (the generators of space inversion with linear momentum). One of the factors in this representation carries the discrete properties of the transformation. The generator of this factor can be expanded in terms of a certain complete set of operators. These operators have a definite group structure. The generality of this result, however, has not been shown. (Dissertation Abstr., 24: No. 11, 1964)

**28456** THE GOLDBERGER, GELL-MANN MODEL. Roscoe Beryl White. Thesis, Princeton, N. J., Princeton Univ., 1963. 73p.

A relativistic model field theory for interacting pion-nucleon fields was developed, making use of many-body or Feynman amplitudes. The model is not exactly solvable, but approximate solutions are constructed and compared with solutions to the partial-wave pion-nucleon dispersion relations. The Bethe Salpeter equation was derived and a variational principle developed for the solution to the scattering problem. Utilizing the variational principle and dispersion techniques the isotopic spin $\frac{3}{2}$ total cross section was calculated and found to give qualitative agreement with experimental results for pion energy greater than 200 Mev, but not to exhibit resonance behavior. (Dissertation Abstr., 24: No. 11, 1964)

**28457** APPLICATION OF NON-LOCAL FIELD OPERATORS TO A SYSTEM OF HARD CORE BOSE GAS. Kai-Wai Wong. Thesis, Evanston, Ill., Northwestern Univ., 1963, 63p.

An Operator Algebra, which takes into account the interparticle boundary conditions implicitly, was developed. Some algebraic relationships with the usual free field operators were also derived. Through these algebraic relationships a Hamiltonian for the many-particle Bose system was obtained in the binary approximation. The Hamiltonian is actually independent of statistics. A calculation of the ground state energy in the pair-wise approximation was performed and found to agree with the result obtained through different methods. The method was also used to study the non-equilibrium case. It was found that the well known superfluid flow equation and the equation of continuity can be derived in the first order approximation of low temperature and low density. In the second order approximation, an equation very similar in form to the classical Boltzmann equation, which in facts give the rate of change of the density of the degenerate single particle state was obtained. There is also an equation in this order of approximation that takes into account the tensor force between particles very similar to an average surface friction between particles. It is mentioned that any other potential can be added on top of the hard core potential. (Dissertation Abstr., 24: No. 11, 1964)

## Geophysics

*Refer also to abstracts 28220, 28225, and 28287.*

**28458** THE VAN ALLEN RADIATION ZONES. II. THE OUTER ZONE, THE GEOMAGNETIC CAVITY, AND MAGNETIC STORMS. W. G. V. Rosser (The University, Exeter, Can.). Contemp. Phys., 5: 255-69(Apr. 1964).

An account is given of the nature and intensity of the particles trapped in the outer radiation zone. The origin of the geomagnetic cavity (or magnetosphere) is discussed. The effects of a typical magnetic storm are described. (auth)

**28459** TOPSIDE SOUNDER OBSERVATIONS OF THE EQUATORIAL ANOMALY IN THE 75° W LONGITUDE ZONE. G. E. K. Lockwood and G. L. Nelms (Defence Research Telecommunications Establishment, Shirley Bay, Ottawa). J. Atmospheric and Terrest. Phys., 26: 569-80 (May 1964).

The equatorial ionosphere was studied by means of top-

side sounder ionograms. During a particular stage in the development of the equatorial anomaly, a ledge of ionization exists above the peak of the F layer. The development and decay of the anomaly is depicted by contours of constant plasma frequency in north-south vertical cross sections of the equatorial ionosphere observed at different times of day. The regions of anomalously high electron density on both sides of the magnetic equator occur where the ledge merges with the peak of the F layer. The presence of dome-like contours is interperted as evidence that ionization is lifted over the equator early in the day. The ledge is interpreted as the upper boundary of ionization which has been redistributed along the field. The movement of ionization along the field and away from the equator creates the regions of high electron density on either side of the equator. An examination of the planetary magnetic indices ($K_p$) suggests that the observed variations in diurnal behavior of the equatorial ionosphere are associated with variations in magnetic activity. (auth)

**28460** THE SUDDEN COMMENCEMENT AND FIRST PHASE OF A GEOMAGNETIC STORM. D. M. Willis (London Univ.). J. Atmospheric and Terrest. Phys., 26: 581-602(May 1964).

The disturbance propagated in the magnetosphere when the particle flux in the solar wind changes abruptly is considered. A plane model is used. It is assumed that the geomagnetic field is terminated at a certain distance by the particle pressure of the solar wind. An abrupt increase of particle density in the stream produces an abrupt increase in the dynamical pressure on the stationary front surface of the solar wind, which tends to push forward the magnetic tubes of force still further. Because of the magnetic elasticity of the magnetosphere, a magnetic disturbance arises, which is propagated, even in a linearized theory, as a succession of discontinuities; for small increases in particle density, the speed of propagation is the local Alfvén speed. The final equilibrium position of the stream surface is considered generally, and numerical estimates are obtained for the final value of the disturbance magnetic field. (auth)

**28461** THE CURRENT THROUGH A RADIOACTIVE POINT IN THE ATMOSPHERE. K. N. Groom and J. A. Chalmers (Durham Univ., Eng.). J. Atmospheric and Terrest. Phys., 26: 603-6(May 1964).

Measurements were made of the current potential gradient and wind speed through a radioactive point. It is concluded that the potential gradient can not be deduced accurately from measurements of the other two factors. (auth)

**28462** IONIZATION OF ARGON IN THE UPPER ATMOSPHERE. A. D. Danilov. Kosmich. Issled., 1: 256-60 (1963).

Argon ionization at the height of 100–200 km is produced by solar ultraviolet radiation. The cross section for absorption of the ultraviolet radiation by argon within the wavelength range of 800–500 Å is $3 \times 10^{-17}$ cm$^2$. This cross section diminishes rapidly with wavelengths shorter than 500 Å. The flux of solar ultraviolet radiation outside the atmosphere is about $1.25 \times 10^{11}$ quanta $\cdot$ cm$^{-2}$ $\cdot$ sec$^{-1}$. The coefficient of argon ionization in space outside the atmosphere was found to be $3.8 \times 10^{-6}$ sec$^{-1}$. Computed values of argon contents in the upper atmosphere, argon ionization speed, and the $A^+$ ion contents are given. The disappearance of argon $A^+$ ions in the upper atmosphere can occur during recombination with electrons or by an ion exchange reaction with neutral atmospheric molecules. Formulas for ion exchange with hydrogen and nitrogen molecules were established. The $A^+$ ion contents at various heights were computed. Maximum ion concentration was found at 180 km. (auth)

**28463** INFLUENCE OF SOLAR ACTIVITY ON THE EARTH'S UPPER ATMOSPHERE. Luigi G. Jacchia (Smithsonian Astrophysical Observatory, Cambridge, Mass.). Planetary Space Sci., 12: 355-78(May 1964).

The fluctuations induced in the Earth's atmosphere by variable polar radiation are discussed. Density and temperature variations in the upper atmosphere caused by solar ultraviolet and corpuscular radiation are considered. Atmospheric perturbations associated with magnetic storms are described. Variable atmospheric density models are also discussed. (C.E.S.)

**28464** PROBLEMS OF DIFFERENTIATION OF FLARES WITH RESPECT TO GEOPHYSICAL EFFECTS. Helen W. Dodson and E. Ruth Hedeman (Univ. of Michigan, Ann Arbor). Planetary Space Sci., 12: 393-418(May 1964).

An attempt is made to differentiate between solar flares on the basis of their terrestrial consequences. Flares are sources of enhanced radiations and/or particle ejections that give rise to measurable changes in the geomagnetic field, the ionosphere, and the particle fields surrounding the Earth. The question of whether flares with detectable geophysical effects differ from flares without such effects is discussed. (C.E.S.)

**28465** THE LISTING OF SUDDEN IONOSPHERIC DISTURBANCES. J. Virginia Lincoln (National Bureau of Standards, Boulder, Colo.). Planetary Space Sci., 12: 419-34(May 1964).

Techniques for observing and determining the properties of sudden ionospheric disturbances are outlined. These disturbances are created abruptly by large increases in absorption in the D region of the ionosphere. They are limited to the sunlit portion of the ionosphere and are considered to be caused by abnormal photon radiation produced at the time of a solar flare. (C.E.S.)

**28466** POLAR CAP ABSORPTION. D. K. Bailey (National Bureau of Standards, Boulder, Colo.). Planetary Space Sci., 12: 495-41(May 1964).

Polar cap absorption (PCA), the intense absorption of radio waves of certain frequencies in their passage through the mesosphere, is discussed. The properties of PCA events, their detection, and their association with solar events are considered. (C.E.S.)

**28467** THE AIR VELOCITY IN BLAST WAVES FROM t.n.t. EXPLOSIONS. J. M. Dewey (Suffield Experimental Station, Alberta, Can.). Proc. Roy. Soc. (London), Ser. A, 27: 366-85(June 9, 1964).

The air velocity was measured in blast waves produced by the detonation of trinitrotoluene charges varying in mass from 30 to 200,000 lb. The technique consists essentially of using a high-speed camera to record the displacement of smoke trails formed close to the charge just before detonation. The initial decay of velocity behind the shock agrees well with theoretical predictions, such as those of Brode, but at later times there is an extended outward flow, which, it is postulated, is caused by the after-burning of the detonation products in the presence of atmospheric oxygen. It was shown that this phenomenon does not occur in the case of the detonation of an explosive with a high oxygen balance, or for a nuclear detonation. The velocity decay within a TNT blast wave may be described by the equation $V = V_s(1 - \beta t) \exp(-\alpha t) + a \ln(1 + \beta t)$ fitted to the

data by an iterative least squares procedure. It was demonstrated that particle trajectories, determined by the smoke tracer technique, may be used to calculate the variations of density, pressure, and temperature within the wave, without reference to other measurements. (auth)

**28468** SPACE RESEARCH, IV. Proceedings of the Fourth International Space Science Symposium, Warsaw, June 4-10, 1963. P. Muller, ed. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 1-997(1964). New York, John Wiley & Sons, Inc., 1964. $37.00.

The upper and lower atmosphere, the ionosphere, the magnetosphere, solar radiation, the interplanetary medium, planets and galactic radiation, and high energy particles were discussed in the 97 papers presented. Separate abstracts are prepared for 50 papers. Four papers previously appeared in NSA (17: 31258, and 18: 2723, 2738, and 16554). (C.E.S.)

*For abstracts of individual papers see: 28214, 28215, 28216, 28217, 28218, 28219, 28220, 28221, 28222, 28223, 28224, 28225, 28226, 28227, 28228, 28287, 28288, 28289, 28290, 28291, 28292, 28293, 28294, 28469, 28470, 28471, 28472, 28473, 28474, 28475, 28476, 28477, 28478, 28479, 28480, 28481, 28482, 28483, 28484, 28485, 28486, 28487, 28488, 28489, 28490, 28491, 28492, 28493, 28494, and 28495.*

**28469** THE IONOSPHERIC F-REGION AND SPACE RESEARCH: A CRITICAL REVIEW. J. A. Ratcliffe (Radio Research Station, Slough, Eng.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 3-7(1964).

The most probable theory for the normal ionization in the F region is outlined, and the doubtful points in this theory are discussed. The abnormal behavior of the F region and possible explanations for this behavior are considered. Experiments aimed at solving the problems mentioned in the discussion are proposed. (C.E.S.)

**28470** REVIEW OF EXCITATION OF AURORAE AND AIRGLOW BY ENERGETIC PARTICLES. B. J. O'Brien (Rice Univ., Houston, Tex.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 8-25(1964).

A critical review is given of the historical development of the present knowledge and the limitations of that knowledge of the excitation of auroras and airglow by nonthermal charged particles that bombard the atmosphere. The historical summary begins with the visual observations of Vegard, and treats the discovery of Doppler-shifted Balmer emissions in auroras. The first direct detection of auroral particle fluxes was made with rockoons from 1953 onwards. Rocket flights showed that electrons with energy of order 10 kev are most important in the excitation of auroras. Satellite studies of electron precipitation showed that these fluxes originated in the magnetosphere at altitudes above 1000 km, and that they can be intense or weak during the day and the night. Simultaneous observations of auroras and the electron fluxes causing them were made with Injun III. The fluxes tend to isotropy over the upper hemisphere. The auroras occur near the high-latitude boundary of trapping, and probably delineate it. The role of Van Allen zone particles in excitation of auroras is discussed. Extensive balloon studies of x rays from precipitated electrons are discussed. The major problem now appears to be a theoretical explanation of the acceleration mechanism causing the particle fluxes that cause the auroras. It is shown that it is unlikely that 5577-Å airglow over North America is excited by particle bombardment, and hence it appears that this airglow is not to be considered a permanent weak aurora. (auth)

**28471** THE AURORA AND THE AIRGLOW. V. I. Krassovskii (Inst. of Atmosphere Physics, Moscow). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 114-29(1964).

Principal facts on the aurora and related airglow are described. Critical remarks are presented, and the necessary objectives of further research are outlined. (auth)

**28472** AN INTERPRETATION OF A ROCKET MEASUREMENT OF ELECTRON DENSITY IN THE LOWER IONOSPHERE. A. C. Aikin (Goddard Space Flight Center, Greenbelt, Md.), J. A. Kane, and J. Troim. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 358-62(1964).

A mid-latitude rocket measurement of electron density is presented for altitudes between 65 and 85 km. An interpretation of the profile indicates that the region between 70 and 85 km is ionized by the action of Lyman alpha radiation on nitric oxide rather than by 2 to 8 Å x rays. Possible explanations are given for a minimum found in the electron density distribution in the vicinity of the mesopause. (auth)

**28473** ELECTRON DENSITIES IN THE D-REGION DEDUCED FROM ROCKET MEASUREMENTS. J. E. Hall (Radio Research Station, Slough, Bucks, Eng.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 363-4(1964).

An experiment designed to measure electron densities in the D-region of the ionosphere is reported. The experiment, in which a low frequency radio wave was propagated from the ground to rocket-borne receiving equipment, is described. The variation in the amplitude of the signal, caused by absorption, polarization changes, and reflection in the ionosphere, was used to derive an electron density profile for the D-region. The radio signal was transmitted from a point beneath the apex of the rocket trajectory and was received on three mutually perpendicular dipole aerials. A frequency of 202 kc was used so that the small electron densities in the D-region would produce measurable effects on the signal. The rockets were not stabilized and the signals received at the individual aerials showed modulation due to the motion of the rocket but, by combining the signals at the three aerials, a scalar field was derived that was independent of rocket attitude. An electron density profile was deduced from the height variation of this scalar field using the following method. A model ionosphere, with particular electron density and electron collision frequency profiles, was assumed, and the wave-field that satisfied the boundary conditions imposed by the polarization of the transmitting aerial was calculated using a full wave treatment. The theoretical variation of the scalar field was derived from this wave-field and compared with its measured value. The model ionosphere was repeatedly adjusted until good agreement was reached. The analysis was not completed but a tentative daytime ionospheric profile can be given. In this, the electron density falls steeply from 4000 electrons/$cm^3$ at 88 km, where the signal was reflected, to about 500 electrons/$cm^3$ at 84 km, whereas between 70 and 84 km the electron density varies only a little between about 300 and 500 electrons/$cm^3$. A similar analysis was made for the night-time experiment but this is less satisfactory as the rocket failed to reach the height at which the signal was reflected. A more detailed analysis of the records will be possible when the results from the attitude measuring devices, carried by the rocket, become available. (auth)

**28474** ELECTRON DENSITIES AND ELECTRIC FIELDS IN THE AURORA. A. Kavadas and D. W. Johnson (Univ. of Saskatchewan, Saskatoon, Can.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 365-70(1964).

Two experiments designed to probe ionospheric microstructure are described. These are an electron density tracking probe and an electric field measuring device. Both devices are small size packages which can be ejected from the rocket. The sampling takes place away from the rocket in order to reduce the effects produced by the large body of the rocket. Electric fields within an auroral display, as measured with this device, are briefly discussed. (auth)

**28475** ROCKET INVESTIGATION OF THE ELECTRICAL STRUCTURE OF THE LOWER IONOSPHERE. R. C. Sagalyn and M. Smiddy (Air Force Cambridge Research Labs., Bedford, Mass.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 371-87(1964).

The electric structure of the D and E regions was investigated on a series of rocket flights using spherical electrostatic analyzers. The concentration of positively and negatively charged particles was obtained at noon, midnight, and sunset over the altitude region 50 to 190 km. The daytime results show a distinct ionized layer in the D region; at 63 km the altitude of maximum ionization the ion density is found to be $2.5 \times 10^4/cm^3$. The ion density decreases to approximately $6 \times 10^3/cm^3$ in this region at midnight. In the E region the ionization intensity is found to be $3 \times 10^5/cm^3$ at 110 km at noon. After sunset the E region charge density decreases rapidly reaching a value of $2 \times 10^3/cm^3$ at 110 km at midnight. On the midnight flight thin ionized layers presumably sporadic E are observed at 100 and 120 km, the charge density is 3 to 7 times higher than that of the surrounding regions. The results show that the negative ion density exceeds the electron density below 75 km during the day and exceeds the electron density by a factor of 1.5 to 100 below 90 km at night. The daytime results are compared with a theoretically deduced charge distribution based on average values for the x-ray, ultraviolet and cosmic-ray flux. The significance of the measured values of the ratios of negative ions to electrons and positive ions to electrons, $N_-/N$ and $N_+/N$, is discussed. The nighttime ratios of $N_-/N$ are used in the solution of the continuity equation assuming quasiequilibrium to det rmine the rate coefficients for associative and collisional detachment and radiative attachment to molecular oxygen. (auth)

**28476** FORMATION OF AN ELECTRON DEPLETED REGION IN THE IONOSPHERE BY CHEMICAL RELEASES. D. Golomb (Air Force Cambridge Research Labs., Bedford, Mass.), N. W. Rosenberg, J. W. Wright, and R. A. Barnes. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 389-98(1964).

The formation of an electron-depleted region in the ionosphere on release of a chemical with a high attachment coefficient for free electrons is reported. About $10^{26}$ molecules of sulfur hexafluoride were released from a rocket-borne pressurized tank at 220 km altitude. Marked perturbations were observed on sweeping and pulsed radio frequency sounders which can be interpreted as resulting from an electron-depleted region as predicted by Booker. The frequencies returned from the region were initially in the 7-8 Mc band, later spreading to cover the 4-8 Mc band, indicating a growth of the electron depleted region. The effect lasted for about 30 minutes. (auth)

**28477** A STUDY OF IONOSPHERIC IRREGULARITIES IN THE AURORAL ZONE USING SATELLITE TRANSMISSIONS AT 54 Mc/s. Ludwik Liszka (Kiruna Geophysical Observatory, Sweden). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 399-406(1964).

Satellite scintillation studies carried out at frequencies 20 and 54 Mc during the last three years are reviewed with emphasis on the 54 Mc results. Studies of diurnal and seasonal variations of scintillation at 54 Mc show that the shape of the diurnal curve is dependent on magnetic activity and that seasonal variations are not important. The depth of scintillation at 54 Mc is better correlated with magnetic activity than at 20 Mc. There exists a difference between daytime and nighttime scintillation, which is indicated by differences in correlation with auroral sporadic E and with magnetic activity. A statistical analysis of the diffraction pattern produced by radio waves from artificial satellites is presented. The most important result is the evidence that auroral zone scintillation may be produced at altitudes below F-maximum. Low altitudes, down to 100 km, of the scintillation-producing region occur more frequently during nighttime. During the forenoon hours, when some of the measurements were made, the scintillation was produced at or above F-maximum. Investigation of the shape of ionospheric irregularities showed that if it is assumed that they are two-axial ellipsoids oriented along the magnetic field lines, axis ratios of order of magnitude 10 will be obtained. (auth)

**28478** CHANGES OF THE DISTRIBUTION OF CHARGED PARTICLE DENSITY WITH HEIGHT AND OF THE IONIC COMPOSITION OF THE OUTER IONOSPHERE SINCE THE SOLAR ACTIVITY MAXIMUM ACCORDING TO DATA COLLECTED BY ION TRAPS ON THE COSMOS 2 SATELLITE. K. I. Gringauz, B. N. Gorozhankin, N. M. Shutte, and G. L. Gdalevich (Academy of Sciences, Moscow). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 473-9 (1964).

In May 1958 experiments on Sputnik 3 established that at heights of 300 to 1000 km in the ionosphere the ion density decreased with height very slowly and atomic oxygen ions dominated. Experiments made in 1962 aboard the Cosmos 2 satellite showed that the decrease of ion density with height in a region immediately above the main ionization maximum up to heights of about 600 km is much more rapid than in 1958. At altitudes exceeding 550 km a considerable number of helium ions is detected. The changes in the structure and ionic composition of the ionosphere seem to be connected with the decrease of solar activity. (auth)

**28479** ELECTRON DENSITY DISTRIBUTION IN THE TOPSIDE IONOSPHERE AT MEDIUM AND HIGH MAGNETIC LATITUDES AND DURING MAGNETIC DISTURBANCES. P. Rothwell (Univ. of Birmingham, Eng.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 480-7 (1964).

Further analysis of electron density data from Ariel I, which has revealed regions of magnetic field aligned enhanced ionization in the topside ionosphere, shows that at medium latitudes ionization was enhanced at intersections of the satellite orbit with the $L \simeq 1.8$ magnetic shell throughout the period April 27-July 12, 1962. The enhancement varied with longitude and also between hemispheres. Electron density was higher in the daytime in the southern hemisphere (local winter) at L = 4-6 (over Australia) than at medium latitude L-values. Ionization density generally increased at medium and high magnetic latitudes in both hemispheres between 400 and 1200 km during small magnetic disturbances. It is suggested that the magnetic field aligned regions of enhanced ionization in the upper ionosphere are produced by particles from the trapping zones of the earth's field precipitated preferentially from certain magnetic shells into the atmosphere. The magnetic storm time increase in density between 400 and 1200 km

may be due both to increased energetic particles precipitation into the atmosphere and to an increased diffusion rate of hydrogen ions downward from the magnetosphere during magnetically disturbed periods. (auth)

**28480** PLASMA TEMPERATURES AND RECOMBINATION PARAMETERS IN THE OUTER IONOSPHERE. K. H. Schmelovskii (Schmelovsky) (Observatorium fur Ionospharenforschung, Kühlungsborn, Ger.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 508-15(1964).

Theoretical investigations, based on rocket and satellite data and on Faraday-fading analysis at 1958 delta 2 showed the following results: Electron temperature in the outer ionosphere is much larger than neutral gas temperature, especially at summer noon. The mean diurnal variations of total electron number and other features of $F_2$-layer and outer ionosphere can be explained by dissociative recombination and ambipolar diffusion, but not the seasonal variations. At winter noon not only the $f_0F_2$ but also the total electron number $N_{tot}$ (up to 1000 km) is larger than at summer noon. Recombination during winter night is not slower than during summer night. Therefore only two possibilities remain: there is a diffusive transport of electrons and ions from summer- to winter-hemisphere along the magnetic field lines; the mixing ratio $(O_2 + N_2)/O$ and with it the recombination coefficient is larger during summer day than during other times. During ionospheric disturbances a decrease of $f_0F_2$ is paralleled by a decrease of $N_{tot}$. Both these are probably caused by an increase of recombination coefficient. (auth)

**28481** IONIZING RADIATION AND HEATING OF THE UPPER ATMOSPHERE. V. I. Lasarev. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 516-24(1964).

The heating of the atmosphere by short-wave and corpuscular ionizing radiation is considered. Studying the photo-chemical processes in the upper atmosphere provides a possibility for calculating the temperature distribution with height. It is shown, that about 40 per cent of the ionizing radiation energy absorbed by the atmosphere is transformed into heat. From data for heating of the upper atmosphere in the daytime the ionizing radiation flux is estimated to be equal to 3-12 erg/cm$^2$ sec. The temperature distribution with height in the night ionosphere is calculated. It is indicated, that the heating of the upper atmosphere at night could be caused by soft electrons with energies exceeding 100 ev the flux of which is equal to 0.4-1.6 erg/cm$^2$ sec. At night the temperature of the order of 700°K was obtained at 200 km; at 350 km it was of the order of 1130°K. (auth)

**28482** ON THE INTERPRETATION OF THE SEASONAL VARIATIONS OF ELECTRON DENSITY IN THE $F_2$ REGION OF THE IONOSPHERE. G. S. Ivanov-Kholodnii. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 525-33(1964).

Seasonal variations of the electron density in the $F_2$ region of the ionosphere, observed by ionospheric sounding stations, are characterized by the anomalous increase of daily $n_eF_2$ in winter, particularly great during the maximum of solar activity. An attempt is made to give an explanation of these variations based on the present photo-chemical theory and mass-spectrometer measurements. The effect of variations of the extreme ultraviolet radiation from the sun and the effect of the density of the upper atmosphere on the ionization of the $F_2$ region are considered. It is concluded that the $n_e$ seasonal anomalies can only be explained on the assumption of diurnal and seasonal variations of the chemical composition at 300 km caused by temperature variations. Some experimental data confirm this assumption. Conclusions that follow from this explanation of the anomalous seasonal variations of $n_e$ are presented. (auth)

**28483** ALFVÉN WAVES IN A DIPOLE MAGNETIC FIELD. Ryszard Gajewski (Inst. for Nuclear Research, Warsaw). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 534-41(1964).

The results of an earlier work on Alfvén waves in inhomogeneous magnetic fields are applied to the case of a dipole field. Numerical solutions of linearized hydromagnetic equations are found and discussed. It is expected that the present results will prove relevant to some phenomena in Earth's magnetic field. (auth)

**28484** INVESTIGATIONS OF THE UPPER ATMOSPHERE USING THE ARTIFICIAL EARTH SATELLITES COSMOS 3 AND COSMOS 5. Yu. I. Galperin and V. I. Krassovskii (Inst. of Atomspheric Physics, Moscow). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963. 563-71(1964).

The apparatus for radiation measurements on Cosmos 3 and Cosmos 5 is described. It consists of two ion traps, five indicators with fluorescent screens and a Geiger counter. Two traps made it possible to detect positive ion currents of from $3 \times 10^5$ to $5 \times 10^6$ ions per cm$^2$ sec sterad and from $3 \times 10^5$ to $3 \times 10^8$ ions per cm$^2$ sec sterad, respectively. Indicators with fluorescent screens covered by aluminum foils of 0.4, 0.6, and 1.1 mg cm$^{-2}$ thickness permitted the detection of electrons in a wide energy range beginning from 40 ev. The signals from electrons of less than 50 kev were modulated by a steplike accelerating voltage. This modulation made it possible to analyze low energy electrons. Also, additional information on electron energies could be gained from comparisons of the data obtained by indicators with different foil thickness and also from the form shape of a modulation of the signal caused by the rotation of the satellite in the anisotropic radiation field. The sensitivity for electrons with energies from 40 ev to 7 kev permitted definite measurements for fluxes from $2 \times 10^8$ to $2 \times 10^6$ electrons per cm$^2$ sec sterad, respectively. The Geiger tube shielded with 3.4 g cm$^{-2}$ Pb + 0.8 g cm$^{-2}$ Al with the geometric factor of 25 cm$^2$ sterad was capable of detecting protons with energies of more than 50 Mev and electrons with energies above 10 Mev. The detector efficiency for bremsstrahlung of lower energy electrons was very low, and electrons of lower than 400 kev energy were practically negligible. (auth)

**28485** INVESTIGATIONS OF THE UPPER ATMOSPHERE USING THE ARTIFICIAL EARTH SATELLITES COSMOS 3 AND COSMOS 5. V. I. Krassovskii, Yu. I. Galperin, N. V. Jorjio, T. M. Mularchik, and A. D. Bolyunova (Inst. of Atmospheric Physics, Moscow). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 572-81(1964).

The results of measurements by ion traps and electron indicators with fluorescent screens on Cosmos 3 and Cosmos 5 are presented. Directional fluxes of positive ions of superthermal energies (apparently between tens of ev and some kilovolts) were observed. The ion fluxes observed were up to ~$10^9$ ions per cm$^2$ per sec per sterad. These fluxes were registered only at low altitudes in the ionospheric F-region. Indicators with fluorescent screens registered low energy electron fluxes with different pitch angle distributions in the magnetic field. Electrons of energies less than 5 kev were observed mostly in the sunlit atmospheric regions. Their velocity distribution is nearly isotropic and their intensity does not vary much with height.

Electrons with energies of 7 to 50 kev appear usually at high geomagnetic latitudes and at high altitudes. Their fluxes amounted to $\sim 10^6$ electrons per $cm^2$ per sec per sterad. Also, much harder particles with a markedly anisotropic distribution typical for trapped radiation, were registered. Comparison of the signals from the fluorescent indicators and the ion traps shows that these particles were electrons of hundreds of kev energy. Their omnidirectional flux amounts to $5 \times 10^7$ electrons per $cm^2$ per sec at heights of about 1000 km. (auth)

**28486** INVESTIGATIONS OF THE UPPER ATMOSPHERE USING THE ARTIFICIAL EARTH SATELLITES COSMOS 3 AND COSMOS 5. V. V. Temny (Inst. of Atmospheric Physics, Moscow). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 582-7(1964).

With the heavy shielded Geiger counter two regions at low altitudes near the Earth are recorded: the region without trapped high energy radiation and the region of trapped protons of more than 50 Mev energy. The lower edge of the trapping zone is determined by atmospheric scattering for altitudes lower than 500 km. For higher altitudes the lower edge lies along a surface of a constant magnetic field B. (auth)

**28487** RECENT OBSERVATIONS OF ELECTRON INTENSITIES IN THE EARTH'S OUTER MAGNETOSPHERE AND BEYOND. L. A. Frank, J. W. Freeman, Jr., and J. A. Van Allen (Univ. of Iowa, Iowa City). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 588-605(1964).

A comprehensive study of the distribution of low energy electrons in the outer portions of the earth's magneto sphere, in and near the geomagnetic equatorial plane, is being made by means of zero-wall-thickness CdS total energy flux detectors and thin-windowed Geiger-Mueller tubes on the long life-time satellites Explorers XII and XIV, whose geocentric apogee distances are 83000 km and 105000 km, respectively. Observations are now available within the outer magnetosphere, at its boundary and beyond, and over a wide range of sun-earth-probe angles from positions on the noon meridian to ones on the midnight meridian. Results of the electron intensity measurements reported herein are concerned with the nature of the interface between the region dominated by the geomagnetic field and the region of the interplanetary medium; evidence for a "piston" of quasi-thermalized solar plasma, consisting predominantly of 1 to 10 kev electrons, on the sunward side of the magnetospheric boundary and having a radial thickness of some 10 000 km; a comprehensive mapping of the omnidirectional intensity of electrons of energy $\geq$40 kev, showing that, near the geomagnetic equatorial plane, the magnetospheric boundary occurs typically at about 10 earth radii at the sub-solar point and has an approximately circular form to a sun-earth-probe angle of about 70°, then flares out to an ogival shape with a radial distance of some 16 earth radii on the dawn meridian; and the discovery of a relative void of electrons of energy $\gtrsim$40 kev on the night side of the earth in a region bounded on its earthward side by the classical region of trapped, outer zone electrons at 7 earth radii and on its outward side by the ogival skirt of much higher intensities. These observations provide a new foundation for the formulation of physical models of the earth's magnetosphere and of the interaction of the solar wind with the geomagnetic field and give a significant measure of coherence to a diverse body of previously discordant observations. (auth)

**28488** MEASUREMENTS MADE IN THE EARTH'S MAGNETOSPHERE BY MEANS OF CHARGED PARTICLE TRAPS ABOARD THE MARS 1 PROBE. K. I. Gringauz, V. V. Bezrukikh, L. S. Musatov, R. E. Rybchinskii, and S. M. Sheronova (Academy of Sciences, Moscow). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 621-6(1964).

Measurements made on November 1, 1962, during the passage of the Mars 1 probe through the magnetosphere confirmed data obtained by means of charged particle traps on Soviet Luniks in 1959 relating to the extension of the Earth's ionized gas envelope to heights of about 18 000–20 000 km. New data were obtained on the outermost belt of charged particles which contains soft electrons. (auth)

**28489** ANALYSIS OF ATMOSPHERIC LOSS RATES FOR GEOMAGNETICALLY TRAPPED ELECTRONS. M. Walt (Lockheed Missiles and Space Co., Palo Alto, Calif.), G. E. Crane, and W. M. MacDonald. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 631-40(1964).

Theoretical analyses of the loss processes for geomagnetically trapped electrons were inconclusive to date due to uncertainties in the magnitude and energy spectrum of the source of natural electrons. However, by comparing theoretical results with the measured time dependence of trapped electrons injected by high altitude nuclear explosions, it is possible to evaluate loss mechanisms and in particular to investigate quantitatively the role of atmospheric scattering. Calculations of the time evolution of the electron flux were carried out using a diffusion equation which includes the effects of both elastic scattering and energy loss processes. The equation is solved as an initial value problem by implicit finite difference techniques. The theoretical results indicate that the initial time rate of change of the electron flux is sensitive to the initial spatial and energy distribution, and for reasonable initial distributions the rate of change is more rapid at low altitudes. In general, the decay rate becomes slower with increasing time, asymptotically approaching an exponential time dependence. The most significant spectral change results from the preferential removal of the low energy electrons. Comparison of the available experimental data with the theoretical results indicates that in the lower region of the magnetosphere, the behavior of trapped electrons is influenced primarily by collisions with atmospheric constituents. (auth)

**28490** OBSERVATIONS ON TRAPPED PROTONS IN EMULSIONS RECOVERED FROM SATELLITE ORBITS. R. Filz (Air Force Cambridge Research Labs., Bedford, Mass.), H. Yagoda, and E. Holeman. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 642-5(1964).

Measurements of the directional flux of $(55 \pm 5)$-Mev protons, in an energy interval of 1.5 Mev, on nuclear emulsions recovered from oriented polar orbit satellites were made over a period of 18 months. When the flux is normalized to an altitude of 400 km a 5-fold increase was observed following the 9 July 1962 thermonuclear burst. The flux prior to this event is constant within a factor of two. Angular measurements on the direction of arrival on the terminating protons indicate that the majority of the particles make small angles with a mirror point plane which is perpendicular to the magnetic field vector in the South Atlantic anomaly. The decay of the injected protons since 9 July 1962 varies erratically and on the basis of the available measurements indicates that the lifetime may be as long as two years but possibly as short as two months. (auth)

**28491** MEASUREMENTS ON TRAPPED PARTICLES INJECTED BY NUCLEAR DETONATIONS. L. Katz (Air

Force Cambridge Research Labs., Bedford, Mass.), D. Smart, F. R. Paolini, R. Giacconi, and R. J. Talbot, Jr. Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 646-64(1964).

A polar-orbiting satellite carried aloft a payload of radiation detection instruments for studying artificially produced trapped-radiation belts. Pertinent information on the satellite's orbit and capabilities is given. Data from four scintillation detectors are presented. The detectors have capabilities for discriminating among types of particles, and for measuring both energy and angular distributions of trapped particles. Data showing spatial distributions of trapped radiation, both as omni-directional flux versus L-shell plots and as iso-intensity contour plots, are presented. The major portion of data presented emphasizes electron pitch angle distributions and derived parameters. Both spatial and temporal variations of the pitch angle distributions are given. Some tentative conclusions are drawn. (auth)

**28492** SOME NEW RESULTS OF SOUNDING OF THE EXOSPHERE. S. Manczarski (Polish Academy of Sciences, Warsaw). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 665-72(1964).

Time signals transmitted by various world-wide radio stations are used for the investigation of radio echoes. These signals are recorded on a magnetic tape. The recording thus obtained is consequently reproduced on an oscillograph and more interesting recording sections are photographed. The experience shows that the exosphere echoes are occurring at the time constituting mostly several per cents of the observation time. It appears, that short waves may penetrate from time to time the ionosphere because of its fibrous structure. They are propagated in the exosphere with the velocity similar to that of light along the dielectric wave ducts which are generated owing to the geomagnetic field. These studies led to the conclusion that there exists in the exosphere a third extra-outer radiation belt at a distance of about 8 Earth radii from the center of the Earth. Successive echoes frequently increased progressively in amplitude, which seem to indicate amplification processes in the plasma. (auth)

**28493** EFFECTS OF TRAPPED PARTICLES IN LOWER IONOSPHERE AT MEDIUM LATITUDES. R. Knuth and E. A. Lauter (Observatorium fur Ionospharenforschung Kuhlungsborn, Ger.). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 673-80(1964).

The significant after-effects of strong magnetic disturbances in low frequency propagation at medium latitudes are probably caused by dumped electrons from the inner part of the outer radiation belt during periods of high refilling. The duration and intensity of these effects correlate well with observed corresponding high energy particle enhancements in satellites. Statistics of such low frequency absorption anomalies indicate a strong dependence on season, sunspot cycle, and geomagnetic latitude which may refer to expected similar variations of trapped particles. (auth)

**28494** ON THE INTERACTION OF THE SOLAR CORPUSCULAR STREAM WITH THE EARTH'S MAGNETOSPHERE. E. I. Mogilevskii (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Propagation, Moscow). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 834-40(1964).

The energy aspect of the interaction of the solar corpuscular stream with the magnetosphere is examined. The estimation shows that even if all the kinetic energy of the solar plasma stream is transferred to the magnetosphere its energy is $10^2-10^3$ times smaller than the average energy of the $D_i$-variation of the geomagnetic field. From the conservation of the density in the phase volume for the cold solar plasma, which streamlines around the magnetosphere it is clear that the latter does not receive energy if the solar plasma has a homogeneous magnetic field (or if the magnetic field is zero). The property of the collisionless solar plasma with a magnetic field is taken into consideration. Only if the solar plasma has its own inhomogeneous magnetic field covering the magnetosphere, can it transfer to the Earth's magnetic field for a long time the energy, which is necessary for a geomagnetic storm. The corpuscular solar stream with a force-free magnetic field satisfies this condition. A half-qualitative model of the energy transfer from the covering magnetic field of the solar stream to the magnetosphere was developed. The non-stationary fast magnetic compression takes place due to the supersonic movement of the magnetic piston from the external magnetosphere to 4 or 5 Earth radii. A system of magnetohydrodynamic shock and automodel waves going from the magnetic piston gradually disintegrated at the height about of 3 Earth radii. The energy stream of these waves and the energy of accelerated particles in the magnetosphere correspond to the power of the $D_i$-variation of the geomagnetic field. The important heating of the magnetosphere arising from the compression of the geomagnetic field and the decay the hydromagnetic shock waves leads to the formation of a continuously changing assymetric circular current. The generation of energetic particles from the bunching instability continuously leaving from the magnetic trap to the polar regions and the generation of the v-l-f plasma waves and radioemission are the main mechanisms of cooling of the external magnetosphere. Near the level of 2 to 3 low frequency magneto-sound waves may be generated that may explain some of the principal properties of ionospheric disturbances. (auth)

**28495** THE EARTH AS NATURAL SPACE PROBE FOR THE STUDY OF SOLAR CORPUSCULAR RADIATION. M. S. Bobrov (Astronomical Council, Academy of Sciences, USSR). Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 925-31(1964)

The effect of solar corpuscular radiation on the magnetosphere gives rise to hydromagnetic impulses propagating down to the Earth and responsible for irregular disturbances $D_i$ of the geomagnetic field. The examination of the $D_i$ planetary pattern may be a means of obtaining information on solar corpuscular radiation. The $D_i$ planetary pattern was examined for more than 60 days with all possible levels of planetary magnetic activity (from an extremely quiet field to very severe magnetic storms). The three principle types of the planetary pattern were found: only polar cap activity; at lower latitudes including the auroral zones the field is quiet; this type is observed on all days with low planetary magnetic activity; apparently it is permanent but on days with greater activity is masked by other kinds of disturbances; it is directly connected with the solar wind; the so-called M-disturbances: moderate activity (centered on the auroral zones) in high and very high latitudes; the duration of such disturbances is of the order of 5-10 days. They tend to be recurrent with a period of 27 days. They are thought to be caused by corpuscular streams from solar plages; world-wide magnetic storms; all latitudes are active; $D_i$ at low latitudes are, as a rule, positive; the storm-time variation is directly visible on magnetograms; short duration (1-2 days); no recurrent tendency. This type is generated by corpuscular streams from solar flares. (auth)

# Low Temperature Physics

*Refer also to abstract 28003.*

**28496** (LAMS-3070) PRESSURE OSCILLATIONS INDUCED BY FORCED CONVECTION HEAT TRANSFER TO TWO PHASE AND SUPERCRITICAL HYDROGEN. Preliminary Experiments. Rodney S. Thurston (Los Alamos Scientific Lab., N. Mex.). Feb. 1964. Contract W-7405-eng-36. 91p.

Pressure oscillations induced by forced convection heat transfer to liquid hydrogen were probed using a preliminary apparatus that cooled from ambient to $LH_2$ temperatures during each run. Acoustic modes due to Helmholtz and open-open pipe resonances were observed at sub- and supercritical pressures. These oscillations did not develop when the inlet hydrogen was superheated. Pressure fluctuations in the form of sawteeth, negative pulses, and beats were also observed above and below the critical pressure. A mode that primarily occurred above the critical pressure and one associated with subcritical two phase flow were also observed. Experimental evidence also indicated that heat transfer was substantially better in two phase flow than in supercritical flow at low flow rates, that pressure drop increased after the apparatus had cooled near $LH_2$ temperatures at moderate flow rates, and that greater axial temperature gradients were obtained in the slower cooldowns. (auth)

**28497** PULSE INDUCED SUPERCONDUCTING TO NORMAL TRANSITIONS IN THIN FILMS. E. M. Hartlin, R. M. Wertheimer, and G. M. Graham (Univ. of Toronto). Can. J. Phys., 42: 1282-99(June 1964).

The superconducting to normal transition in thin films of Al, Sn, In, and Pb was studied by applying square voltage pulses to a coaxial line terminated by the film and observing the reflected pulse shape. Interest centered on the nearly isothermal transitions which could be induced below the lambda temperature of liquid helium. The results were analyzed in terms of the nucleation and growth of normal domains. The use of very rapidly rising pulses allowed an estimation of the nucleation time of a normal domain as not more than $3 \times 10^{-10}$ second. The number of nucleation sites was a sensitive function of the current density in the film. The subsequent growth of normal domains proceeded with a velocity characteristic of the material, of the order of the velocity of transverse sound waves in the bulk metal. Roughly the same velocity was deduced for normal domain growth both parallel and perpendicular to the direction of the current in the film. Growth velocities smaller than these were not observed, but the "pinning" of domain boundaries by defects in the film was encountered. (auth)

**28498** STRONG MAGNETIC FIELDS. J. L. Olsen (Swiss Federal Inst. of Tech., Zurich). Contemp. Phys., 5: 161-79(Feb. 1964).

Methods presently available for producing strong magnetic fields are described. The classical electromagnet of moderate size is very reliable and relatively cheap. Once fields greater than about 40,000 gauss are required, then the ratio of magnet size to useful volume becomes enormous. In fields up to about 100,000 gauss iron-free solenoids at room temperature or very soon superconducting coils will be used. For still higher fields up to about 250,000 gauss very powerful room temperature solenoids or coils made of superconductors yet to be developed can probably be used. Above these fields only the pulsed field techniques seem to be feasible. With these fields up to 18 megagauss have been achieved. (auth)

**28499** ELIMINATION OF THE EDGE EFFECT IN SUPERCONDUCTING INDIUM AND TIN FILMS. I. Ames and H. Seki (International Business Machines Corp., Yorktown Heights, N. Y.). J. Appl. Phys., 35: 2066-8 (July 1964).

Superconducting thin film strips of indium and tin from 3000 to 10,000 Å thick having sharp, magnetically induced resistive transitions between their superconducting and normal states, were produced. Usually, the width of such transitions may be as much as 50 to 100% of the critical field because of the relatively high fields required to switch the thinner, tapered edges of the films. This tendency was counteracted by preferentially depressing the critical temperature near the film edges through the use of an overlapping film of copper or gold, up to several hundred angstroms thick. Transition sharpening equivalent to that observed when the edges of the superconducting films are mechanically removed was thus achieved. Behavior predicted by analyses of a simplified model was found to be consistent with experimental observations. (auth)

**28500** EFFECTIVE THERMAL CONDUCTANCE FROM A THIN FILM INTO LIQUID HELIUM. H. Seki and I. Ames (International Business Machines Corp., Yorktown Heights, N. Y.). J. Appl. Phys., 35: 2069-73(July 1964).

The steady-state thermal dissipation from heat-generating thin-film strips, immersed in liquid helium, was examined by measuring the thermal hysteresis of the magnetically induced resistive transition of superconducting thin films of tin deposited on glass and aluminum substrates. The dissipated heat was found to depend linearly on the temperature difference between the film strip and the helium bath. It was thus possible to characterize the heat transfer by an effective coefficient of heat transfer that was approximately ten times as great for films on aluminum substrates as for films on glass substrates. For a $0.12 \times 2.3$ mm$^2$ film strip, its value was approximately $8 \times 10^{-3}$ w/°K for the aluminum substrate and approximately $9 \times 10^{-4}$ w/°K for the glass substrate. The coefficient was also dependent on the nature of other thin films deposited beneath or above the film strip. Analysis of the data indicated that the thermal conductance between the film strip and the helium bath was about 0.1 w/cm$^2$ °K, and the thermal conductance between the film strip and the aluminum about 1.7 w/cm$^2$ °K. (auth)

**28501** PREPARATION AND PROPERTIES OF THIN-FILM HARD SUPERCONDUCTORS. J. Edgecumbe, L. G. Rosner, and D. E. Anderson (Univ. of Minnesota, Minneapolis). J. Appl. Phys., 35: 2198-2202(July 1964).

Films of thickness the order of 1000 Å of Nb–Zr, Nb–Ti, Ti–V, V–Si, Nb–Sn, and Nb were prepared by d-c sputtering and by electron bombardment evaporation. Measurement of the critical current $J_c$ as a function of external magnetic field H was carried out at 4.2°K by using pulsed magnetic fields and pulsed currents. The films have $J_c$ vs H characteristics and transition temperatures very similar to those reported for bulk hard superconductors. An exception was the sputter-deposited Nb, $T_c \approx 9$°K, which was superconducting at 70 kOe and $10^3$ amp/cm$^2$. More structure was observed in the $J_c$ vs H characteristic for longitudinal configuration than previously reported. (auth)

**28502** THEORY OF ADSORPTION OF THE ISOTOPIC HYDROGEN MOLECULES AT LOW TEMPERATURES. A. Katorski and David White (Ohio State Univ., Columbus). J. Chem. Phys., 40: 3183-94(June 1, 1964).

A theory of the adsorption of isotopic hydrogen molecules is developed in which the potential of interaction of the ad-

sorbed molecule with the plane surface is a function of two parameters. The Schrödinger equation is solved for the rotation-vibrational energy levels of the diatomic molecules in the adsorbed state. From these energy levels, isotopic and ortho-para separation factors and heats of adsorption are calculated by statistical thermodynamics. There is a reasonable correspondence between experimental separation factors and heats of adsorption derived from chromatographic experiments and those computed from the theory for selected values of the potential parameters. The sequence of relative volatilities of the hydrogen isotopes and ortho-para species found experimentally is in accord with that predicted from the theory. Both the separation factors relative to para hydrogen and the heats of adsorption increase in the order; o-$H_2$, HD, HT, o-$D_2$, p-$D_2$, DT, p-$T_2$, and o-$T_2$. (auth)

**28503** DIELECTRIC POLARIZABILITY OF FLUID PARA-HYDROGEN. John W. Stewart (National Bureau of Standards, Boulder, Colo.). J. Chem. Phys., 40: 3297-3306(June 1, 1964).

The dielectric constant of liquid and gaseous para-hydrogen was measured by the capacitance ratio method between 24 and 100°K and 2-326 atm, encompassing the density range 0.002-0.080 g/cm$^3$. These data were combined with recently available PVT results in order to calculate the Clausius-Mossotti (CM) function to 0.05% precision. In the range considered, the CM function, or polarizability, instead of being constant, initially rises with density to a maximum 0.2% above the low density value of 1.00427 cm$^3$/g, and then falls. The data in this range can be represented within experimental error by a quadratic function of density. The deviation from constancy is too small for detailed correlation with existing theories of polarizability to be feasible. The results are presented in tabular form. Also the dielectric constant at any desired density can easily be calculated to an accuracy better than 0.1% in $\epsilon - 1$ from the function fitting the polarizability. (auth)

**28504** HEAT CAPACITY OF SOLID HD. George Grenier and David White (Ohio State Univ., Columbus). J. Chem. Phys., 40: 3451-2(June 1, 1964).

The heat capacity of solid HD along the saturation curve was measured from 2.5 to 15°K. The Debye $\theta_0$ ($\theta$ at 0°K) was estimated to be 110 ± 3°. The difference of this value from those for $D_2$ and $H_2$ is discussed, and an explanation is presented for the rapid rise of the heat capacity with decreasing temperature. (D.C.W.)

**28505** THE PENETRATION DEPTH IN SEVERAL HARD SUPERCONDUCTORS. T. J. Greytak and J. H. Wernick (Bell Telephone Labs., Murray Hill, N. J.). J. Phys. Chem. Solids, 25: 535-42(June 1964).

The magnetic penetration depth in the superconducting intermetallic compounds $V_3Si$, $V_3Ga$, $V_3Ge$, and $V_3Pt$ and in tantalum was studied by means of a coil whose inductance was made to depend on this parameter. Difficulty was experienced in finding samples of the intermetallic compounds with sharp enough superconducting transitions to allow quantitative measurements to be made. However, quantitative results were obtained for $V_3Si$ and tantalum which showed that below the transition region, in the temperature range studied, the magnetic field penetration depth varied linearly with $y = (1 - (T/T_c)^4)^{-\frac{1}{2}}$. For $V_3Si$ the slope of this line, $\lambda_0$, was found to be 2300 Å to an accuracy +10 and −30%. For tantalum, $\lambda_0$ was 1500 Å ±50%. From these figures, the BCS theory was used to find a zero temperature penetration depth $\lambda(0)$, and a coherence distance, $\xi_0$. The relative values of $\lambda(0)$ and $\xi_0$ confirmed that these materials are hard superconductors in the negative surface energy sense. (auth)

**28506** ALTERNATING CURRENT LOSSES IN SUPERCONDUCTORS. B. F. Figgins and T. A. Shepherd (British Oxygen Co., Ltd., London). Nature, 202: 890(May 30, 1964).

The loss of power due to variations of current distribution above threshold in lead-bismuth eutectic alloy was investigated by monitoring the helium gas boiled off from the liquid surrounding the specimen. (R.E.U.)

**28507** A FIELD-THEORETICAL METHOD IN THE THEORY OF SUPERCONDUCTIVITY. [PART] II. G. Pőcsik (Roland Eötvös Univ., Budapest) and A. Zawadowski. Nuovo Cimento (10), 32: 1110-12(May 16, 1964).

It was shown previously, for the case of a contact interaction, that in the pole approximation the exact equations of the simple correlation functions lead to the usual superconducting solutions. Pole approximation implies only one stable excited state contributing to the correlation functions. The method is extended for more realistic smeared-out interactions. Expressions for the energy gap, excitation amplitude, ground energy, and chemical potential are derived. (M.J.T.)

**28508** POSSIBLE DETECTION OF ABRIKOSOV'S STRUCTURE THROUGH INTERFERENCE EFFECTS IN JOSEPHSON TUNNELING. K. Maki (Kyoto Univ.). Phys. Letters, 10: 11-12(May 15, 1964).

Two cases in which the interference effects in Josephson tunneling may be used to directly measure the Abrikosov structure in type II superconductors are discussed. (C.E.S.)

**28509** FLUX COMPRESSION IN HARD SUPERCONDUCTORS. H. J. Goldsmid and J. M. Corsan (General Electric Co. Ltd., Wembley, Eng.). Phys. Letters, 10: 39-40 (May 15, 1964).

Magnetic flux compression experiments were performed on $Nb_3Sn$ superconductors using a tube-piston apparatus of simple geometry. Experimental and theoretical values of the final field are compared. (C.E.S.)

**28510** THE ANGULAR DEPENDENCE OF SURFACE SUPERCONDUCTIVITY IN SOME TYPE I AND TYPE II LEAD BASED SUPERCONDUCTORS. H. R. Hart, Jr. and P. S. Swartz (General Electric Research Lab., Schenectady, N. Y.). Phys. Letters, 10: 40-1(May 15, 1964).

Evidence for superconductivity above the thermodynamic critical field and the Abrikosov critical field in type I and II lead-based superconductors was found. Its origin is attributed to a superconducting surface layer. It is found that the superconducting field is sensitive to the angle $\theta$ between the magnetic field and the plane of the surface. The superconducting field is maximum at $\theta = 0$. Lead and lead-thallium superconductors were used. (C.E.S.)

**28511** ROLE OF THE INTERMETALLIC COMPOUNDS IN DETERMINING THE SUPERCONDUCTING TRANSITION TEMPERATURE OF SUPERIMPOSED METAL FILMS. H. L. Caswell (International Business Machines Corp., Yorktown Heights, N. Y.). Phys. Letters, 10: 44-5(May 15, 1964).

The effect of intermetallic compounds of $AuPb_3$ and $AuPb_2$ formed by diffusion on the superconducting transition temperature of superimposed films of Pb and Au was investigated. (C.E.S.)

**28512** QUANTUM EFFECTS IN TYPE II SUPERCONDUCTORS. J. E. Zimmerman and A. H. Silver (Ford

Motor Co., Dearborn, Mich.). Phys. Letters, 10: 47-8 (May 15, 1964).

Observations of quantum interference effects in type II superconductors, i.e., the periodic or oscillating variation of critical current with applied field, are reported. The quantum interference effects are viewed as a demonstration of fluxoid quantization. Thin superconducting wires and tapes of Nb, Ta, and V were used. (C.E.S.)

**28513** SWITCHING TIMES OF THE CURRENT-INDUCED, SUPERCONDUCTING-TO-NORMAL TRANSITION IN FILAMENTS OF TIN AND INDIUM. J. I. Gittleman and S. Bozowski (RCA Labs., Princeton, N. J.). Phys. Rev., 135: A297-9(July 20, 1964).

The superconducting-to-normal switching time was measured by comparing the electric pulse incident on a filamentary superconductor with the pulse transmitted by it. The switching time was found to vary inversely with the excess of the current pulse over the critical current. In the limit of large current pulses, the switching time became less than about $5 \times 10^{-11}$ sec. (auth)

**28514** BULK ABSORPTION OF RADIATION IN SUPERCONDUCTORS. Ernest E. H. Shin (Massachusetts Inst. of Tech., Cambridge). Phys. Rev., 135: A299-305 (July 20, 1964).

Perturbation theory is applied to calculate the spectral shape of the bulk absorption of radiation in a superconductor. The second-order processes involving one photon and one phonon are considered. The resulting spectrum exhibits a spike near the frequency corresponding to the energy gap. This is attributed to the large values of the BCS density of states at the gap edges. (auth)

**28515** ELECTRON TUNNELING INTO SUPERCONDUCTING MERCURY FILMS. Stuart Bermon and D. M. Ginsberg (Univ. of Illinois, Urbana). Phys. Rev., 135: A306-16(July 20, 1964).

Tunneling measurements were made on junctions consisting of evaporated films of aluminum and mercury separated by an aluminum oxide insulating layer. The width of the superconducting mercury energy gap extrapolated to T = 0°K was determined to be $2\Delta(0) = (1.65 \pm 0.04) \times 10^{-3}$ ev = $(4.60 \pm 0.11)k_BT_c$ from the current-voltage characteristic with the junction in the superconductor-insulator-superconductor configuration. Comparison is made with theory, and with thermodynamic and spectroscopic measurements of the gap. Measurements of the differential conductance in the vicinity of the gap in the metal-insulator-superconductor configuration show qualitative agreement with curves calculated from a BCS density of states, although the experimental curves are more peaked and have a larger tail at low bias voltages. The temperature dependence of the gap, as indicated by the differential conductance at zero bias, was found to agree closely with the BCS variation, provided that the BCS curve is scaled by a constant multiplier. Structure, thought to be related to the phonon spectrum of mercury, was observed in the first and second derivatives of the tunneling current. (auth)

**28516** SUPERCONDUCTIVITY OF TUNGSTEN. J. W. Gibson and R. A. Hein (Naval Research Lab., Washington, D. C.). Phys. Rev. Letters, 12: 688-90(June 22, 1964).

Superconductivity was observed in a sample of high-purity tungsten. The transition temperature was determined to be not greater than 0.011°K. Calculations suggest a lower limit of 0.005°K. (M.J.T.)

**28517** THEORETICAL LIQUID STRUCTURE FUNCTION FOR LIQUID $He^4$ AT T = 0. Walter E. Massey (Washington Univ., St. Louis). Phys. Rev. Letters, 12: 719-20(June 29, 1964).

A theoretical calculation of the liquid structure function, S(K), which exhibits an experimentally determined shoulder in the neighborhood of $K = 0.6$ Å$^{-1}$ is reported. Results of calculations of the radial distribution function and the liquid structure function, using two different trial functions, are compared with previous experimental results. (M.J.T.)

**28518** INELASTIC SCATTERING OF COLD NEUTRONS BY CONDENSED ARGON. N. Kroo, G. Borgonovi, K. Skoeld, and K. E. Larsson (Aktiebolaget Atomenergi, Studsvik, Sweden). Phys. Rev. Letters, 12: 721-2(June 29, 1964).

The question of the existence of collective modes of heat motion in liquids was investigated by neutron inelastic scattering measurements on liquid argon at 88°K and on solid polycrystalline argon at 80°K. Energy spectra of scattered neutrons were analyzed at angles from 60 to 100°, for an incident wavelength of 4.1 Å. Dispersion curves are obtained and plotted; derived sound velocities are compared with other experimental values. (M.J.T.)

**28519** PROPOSED NOMENCLATURE FOR HELIUM ALLOTROPES. J. G. Daunt (Ohio State Univ., Columbus), A. F. Schuch, and R. L. Mills. Phys. Today, 17: 50-1 (Jan. 1964). (LADC-5459)

Inconsistencies in the present system of nomenclature for helium allotropes were noted, and a system was proposed in which the solid phases are labeled by symbols indicating their crystal structure. (D.C.W.)

**28520** SUPERCONDUCTIVITY OF AN ELECTRON SYSTEM WITH SINGLET OR TRIPLET PAIRS. S. V. Vonsovskii and M. S. Svirskii (Inst. of Metal Physics, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1619-20(May 1964). (In Russian)

The effect of the symmetry type of the coordinate part of an electron (Cooper) pair wave function on establishment of a superconducting state is investigated. The exchange parts of the matrix elements characterizing the electron conduction interaction induced by Coulomb forces and also by spin waves of the ferro- or antiferromagnetic are determined. The effect which the exchange part exerts on establishment of a superconducting state with singlet or triplet pairs is discussed. Modifications in the theory which should make it possible to include triplet pairs in the BCS, Bogolyubov canonical transformation, and two-time Green temperature function methods are considered. (auth)

**28521** HYDRODYNAMICS OF ROTATING HELIUM II IN A RING CHANNEL. M. P. Kemoklidze and I. M. Khalatnikov (Inst. of Physics, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1677-9(May 1964). (In Russian)

An equation which yields the velocity field in rotating helium II in the general case is derived by a variational method. It is shown that for a ring channel, formation of an internal irrotational region with a circulation that greatly exceeds the circulation quantum h/m is energetically most favorable. (auth)

**28522** THERMAL CONDUCTIVITY OF THE INTERMEDIATE STATE OF SUPERCONDUCTORS. A. F. Andreev (Inst. of Physics, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1823-8(May 1964). (In Russian)

It is demonstrated that as a result of superbarrier reflection of electron excitations at the boundary between the normal and superconducting phases in the presence of

a thermal flow, a temperature discontinuity arises. The additional thermal resistance of the superconductor in the intermediate state is calculated. It is found to grow exponentially with decreasing temperature and is independent of the electron mean free path. (auth)

**28523** ON WEAKENED CURRENT DISTRIBUTIONS. A. N. Lebedev (Lebedev Inst. of Physics, Moscow). Zh. Tekhn. Fiz., 34: 812-17(May 1964). (In Russian)

Azimuthally-symmetric weakened current distributions, in which the relation of current density to magnetic field is a function of the coordinates, were investigated. The condition for the existence of such a distribution was found, and the general form of the solution, which depends on a scalar function satisfying the nonlinear wave equation, was obtained. (tr-auth)

**28524** A NEW HIGH FIELD SUPERCONDUCTOR ALLOY. 12p. (CONF-524-6).

From American Institute of Mining, Metallurgical and Petroleum Engineers Annual Meeting, New York, Feb. 1964.

The superconducting properties of a Nb–40 wt % Ti alloy were investigated. (C.E.S.)

**28525** HIGH FIELD SUPERCONDUCTIVITY RESEARCH. J. E. Kunzler (Bell Telephone Labs., Inc., Murray Hill, N. J.). 42p. (CONF-433-6)

From American Society Testing Materials 1964 International Conference on Materials, Philadelphia, Feb. 1964.

The properties, theory, preparation, fabrication, and uses of high-field, high-current superconductors are discussed, particularly in relation to the production of strong magnetic fields. Uses involving their high critical current density and magnetic shielding properties are also covered. The desirable properties of $Nb_3Sn$ and techniques developed for its fabrication are considered in some detail, as are the characteristics and performance of $Nb_3Sn$ magnets. 47 references. (D.C.W.)

**28526** SUPERCONDUCTIVITY AND VACANCY STRUCTURES OF THE PRESSURE INDUCED SODIUM CHLORIDE-LIKE PHASES OF THE In–Te SYSTEM. S. Geller, A. Jayaraman, and G. W. Hull, Jr. (Bell Telephone Labs., Inc., Murray Hill, N. J.). 8p. (CONF-524-7)

From American Institute of Mining, Metallurgical and Petroleum Engineers Annual Meeting, New York, Feb. 1964.

A solid solution range of Te was observed in the NaCl phase induced in In–Te by compression and heating. The compounds are actually deficient in In; the formulas can be written $In_{1-x}Te$, with $0 \leq X \leq 0.18$. The density of $In_{0.82}Te$ indicates that each unit cell contains an average of 0.64 vacancies in In sites. Superconductivity exists in the whole composition range. The transition temperature and lattice constant decrease with In/Te ratio. An explanation of the metallic behavior of these compounds is presented which also appears to account for the dependence of Te on the In/Te ratio. (D.C.W.)

## Neutron Physics

*Refer also to abstracts 28717 and 28978.*

**28527** (AE-140) AN EXTENDED GREULING-GOERTZEL APPROXIMATION WITH A $P_n$-APPROXIMATION IN THE ANGULAR DEPENDENCE. Rune Hakansson (Aktiebolaget Atomenergi, Stockholm). Apr. 1964. 21p.

The slowing-down spectrum was calculated for different media. It is given in slab geometry as a function of space at the beginning of the epithermal region (10 ev). The angular dependence is also shown. The basic method is that given by E. Greuling, F. Clark, and G. Goertzel, but in this report it is permissible to include more terms in the Legendre expansion. (auth)

**28528** (AERE-R-4582) A COMPILATION OF THE SCATTERING LAW FOR HEAVY WATER AT 22°C AND 150°C. B. C. Haywood (United Kingdom Atomic Energy Authority. Reactor Group. Atomic Energy Research Establishment, Harwell, Berks, England). May 1964. 14p.

The scattering law for $D_2O$ at 22 and 150°C are presented in the form of listings of the experimental data. The possible absolute and relative errors are considered and estimates of the best lines through the experimental points are listed for guidance. (auth)

**28529** (NAA-SR-8683) THE AGE OF FISSION NEUTRONS TO INDIUM RESONANCE ENERGY IN GRAPHITE. PART I. EXPERIMENT. R. W. Campbell, R. K. Paschall, and V. A. Swanson (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). June 15, 1964. Contract AT-11-1-GEN-8. 28p.

The age of fission neutrons to indium resonance energy was measured in AGOT graphite using the point source technique. Corrections to the data arising from the following factors were investigated: (a) source and foil size, (b) finite dimensions of medium, (c) higher and/or lower energy activations, and (d) foils are not scaler flux detectors. The age was determined to be 307.8 $cm^2 \pm 2.0$ $cm^2$ and the fourth and sixth moments were $6.577 \times 10^6$ $cm^4$ and $3.843 \times 10^{10}$ $cm^6$, respectively. These compare favorably with the values of 307.4 $cm^2$, $6.590 \times 10^6$ $cm^4$, and $4.006 \times 10^{10}$ $cm^6$ obtained by Monte Carlo calculations. (auth)

**28530** (WAPD-BT-30(p.41-6)) DIFFERENTIAL EQUATIONS FOR DOPPLER-BROADENED CROSS SECTIONS. D. R. Harris (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh).

Neutron cross sections can be computed at finite temperature by performing integral operations on zero-temperature cross sections. Alternatively, Doppler-broadening cross sections can be computed as solutions to certain partial or total differential equations. Such equations were derived previously for the approximate Bethe-Placzek form of the Doppler-broadening integral. Corresponding partial and total differential equations are here derived for exact Doppler broadening and for a case of intermediate accuracy. An integral operation is derived to permit exact computation of cross sections at a finite temperature in terms of cross sections specified at a lower but nonzero temperature. (auth)

**28531** NEUTRON MODERATION IN NON-HOMOGENEOUS MEDIA. Yu. A. Platovskikh (Central Scientific Research Inst., USSR). Inzh. Fiz. Zh., 7: No. 2, 62-5(Feb. 1964). (In Russian)

Moderation of neutrons in non-homogeneous medium is studied for plane geometry on the basis of the age-diffusion approximation. A formula for the definition of changes in the mean square length of moderation in non-homogeneous medium is given. (auth)

**28532** SPATIAL EXPANSION OF THE TRANSPORT EQUATION. G. C. Pomraning and M. Clark, Jr. (Massachusetts Inst. of Tech., Cambridge). J. Nucl. Energy, Pt. A & B, 18: 191-209(Apr. 1964).

The solution of the monoenergetic transport equation in slab geometry is expanded in terms of known spatial functions and unknown angular coefficients. Two general for-

malisms—a variational method and a moment-conservation method—are developed to obtain the necessary equations for the angular coefficients. The latter formalism is emphasized since it always yields neutron conservation. Further, it is shown that this formalism treats exactly any incident flux boundary condition, including the discontinuous vacuum boundary condition. For small systems with a highly peaked directional flux, a spatial expansion of the directional flux in integer powers of z (the spatial co-ordinate) is shown to yield extremely good results. Thus, a polynomial expansion forms a complement to the widely used angular expansions, such as the P-N (spherical harmonic) method, which are most accurate for large systems with an almost isotropic directional flux. To emphasize the fact that the formalisms developed are applicable to any spatial expansion functions, the penetration (of a normal beam) problem is considered with exponential expansion functions. The analysis is shown to reduce to the exact transport result in all known limits. (auth)

**28533** THE EMISSION OF NEUTRONS FROM RADIUM SOURCES. E. J. Axton and J. W. G. Dale (National Physical Lab., Teddington, Middx., Eng.). J. Nucl. Energy, Pt. A & B, 18: 211-12(Apr. 1964).

The neutron emission rates from $RaCl_2$, $RaSO_4$, and $RaBr_2$ sources were measured to be from 60 to 120, 11 to 21, and 4 to 8 n/sec/mg, respectively, in agreement with the findings of De Troyer and Tavernier. Measurements of neutron escape from a manganese sulfate both indicate that neutrons from radium sources are less energetic than those from a Ra–Be ($\alpha$,n) source, but are more energetic than Ra–Be photoneutrons. The effects of purity and cladding on the observed emission rates are discussed. (D.C.W.)

**28534** ANALYTIC TESTS OF THE MULTIGROUP DESCRIPTION. Harvey Amster (Univ. of California, Berkeley). Trans. Am. Nucl. Soc., 7: 1(June 1964).

**28535** INDIRECT DETERMINATION OF ANGULAR DISTRIBUTIONS. G. R. Dalton and R. M. Satterfield (Univ. of Florida, Gainesville). Trans. Am. Nucl. Soc., 7: 4-5 (June 1964).

**28536** A VARIATIONAL PROCEDURE FOR CALCULATING HIGH-ENERGY, FEW-GROUP, SPATIALLY DEPENDENT SPECTRA. P. A. Ombrellaro (Knolls Atomic Power Lab., Schenectady, N. Y.). Trans. Am. Nucl. Soc., 7: 10-11(June 1964).

**28537** LEAST-SQUARES VARIATIONAL METHODS. Martin Becker and Henri Fenech (Massachusetts Inst. of Tech., Cambridge). Trans. Am. Nucl. Soc., 7: 11-12(June 1964).

**28538** A MONTE CARLO STUDY OF THE TRANSPORT OF NEUTRONS RESULTING FROM PROTON-INDUCED NUCLEAR EVAPORATION. M. B. Wells (Radiation Research Associates, Inc., Ft. Worth, Tex.). Trans. Am. Nucl. Soc., 7: 17(June 1964).

**28539** A VARIATIONAL TECHNIQUE FOR SPACE-TIME NEUTRON DIFFUSION. J. W. Riese (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 22-3(June 1964).

**28540** THE INPUT-OUTPUT PROBLEM IN TWO-DIMENSIONAL NEUTRON DIFFUSION PROGRAMS WITH LARGE MESHES. W. R. Cadwell (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 23-4(June 1964).

**28541** THE PRODUCTION, DISTRIBUTION AND CONSUMPTION OF MICROSCOPIC NEUTRON CROSS SECTIONS. Herbert Goldstein (Columbia Univ., New York). Trans. Am. Nucl. Soc., 7: 24(June 1964).

**28542** THE WKB METHOD IN THE STUDY OF NEUTRON THERMALIZATION IN GRAPHITE. Ajoy K. Ghatak (Brookhaven National Lab., Upton, N. Y.). Trans. Am. Nucl. Soc., 7: 25-6(June 1964). (BNL-7812)

**28543** ESCAPE PROBABILITIES BY THE METHOD OF INVARIANT IMBEDDING. D. S. Dodson and J. O. Mingle (Kansas State Univ., Manhattan). Trans. Am. Nucl. Soc., 7: 26(June 1964).

**28544** SLOWING DOWN OF NEUTRONS IN THE VICINITY OF A RESONANCE. Rubin Goldstein (Univ. of California, Berkeley). Trans. Am. Nucl. Soc., 7: 28-9 (June 1964).

**28545** COMPARISON OF EXACT AND APPROXIMATE TREATMENTS OF RESONANCE EFFECTS IN CYLINDRICAL LATTICES. F. T. Adler and E. E. Lewis (Univ. of Illinois, Urbana). Trans. Am. Nucl. Soc., 7: 29-30(June 1964).

**28546** SCATTERING KERNELS FOR $H_2$ AND $D_2$. James A. Young and Juan U. Koppel (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Trans. Am. Nucl. Soc., 7: 30-1(June 1964).

**28547** COMPARISON OF MEASURED AND CALCULATED FAST-NEUTRON PENETRATION AND REFLECTION DATA FOR POLYETHYLENE AND STEEL. R. L. Henry, L. G. Mooney, and J. R. Stokes (General Dynamics, Fort Worth, Tex.). Trans. Am. Nucl. Soc., 7: 40-1(June 1964).

**28548** MEASUREMENTS OF THE DIFFUSION PARAMETERS OF CARBON BLACK. E. Starr (New York Univ., New York) and J. W. L. Devilliers. Trans. Am. Nucl. Soc., 7: 45(June 1964).

**28549** REACTOR-PULSE PROPAGATION THROUGH GRAPHITE. G. H. Miley and P. K. Doshi (Univ. of Illinois, Urbana). Trans. Am. Nucl. Soc., 7: 45-6(June 1964).

**28550** APPROACH TO EQUILIBRIUM OF A NEUTRON PULSE IN GRAPHITE. Ajoy K. Ghatak and Henry C. Honeck (Brookhaven National Lab., Upton, N. Y.). Trans. Am. Nucl. Soc., 7: 46-7(June 1964). (BNL-7823)

**28551** USE OF THERMAL-NEUTRON MODAL AMPLITUDES AS DETERMINED BY THE PULSED-SOURCE TECHNIQUE FOR MEASUREMENT OF SLOWING-DOWN KERNELS. J. R. Wolberg (Israel Inst. of Tech., Tel Aviv) and T. Gozani. Trans. Am. Nucl. Soc., 7: 50-1(June 1964).

**28552** MULTIPLYING-MEDIUM ASYMPTOTIC SPECTRUM. R. E. Slovacek (Rensselaer Polytechnic Inst., Troy, N. Y.), E. R. Gaerttner, R. R. Fullwood, and D. R. Bach. Trans. Am. Nucl. Soc., 7: 51-2(June 1964).

**28553** TIME EIGENVALUES AND DEGENERATE KERNELS IN THERMALIZATION. Noel Corngold and Charles S. Shapiro (Brookhaven National Lab., Upton, N. Y.). Trans. Am. Nucl. Soc., 7: 52-3(June 1964). (BNL-7842)

**28554** AN INVESTIGATION OF SLOWING-DOWN PARAMETERS FOR NEUTRONS IN LIQUID HYDROGEN. Victor H. Bouquet, Jr. (Air Force Systems Command, Los Angeles). Trans. Am. Nucl. Soc., 7: 63(June 1964).

**28555** THE AGE OF FISSION NEUTRONS TO INDIUM RESONANCE ENERGY IN ZIRCONIUM/WATER MIXTURES. R. K. Paschall (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 76-7(June 1964).

**28556** ENERGY-DEPENDENT EXTRAPOLATION-LENGTH MEASUREMENTS IN POLYETHYLENE. R. Fullwood, R. Slovacek, R. Cerbone, and E. Gaerttner (Rensselaer Polytechnic Inst., Troy, N. Y.). Trans. Am. Nucl. Soc., 7: 77(June 1964).

**28557** A MEASUREMENT OF $\alpha$ FOR URANIUM-235 IN THE EPITHERMAL REGION. L. J. Esch, F. Feiner, J. L. Mewherter, A. F. Heitcamp, and H. M. Eiland (Knolls Atomic Power Lab., Schenectady, N. Y.). Trans. Am. Nucl. Soc., 7: 78-9(June 1964).

**28558** 10,000-HOUR DEMONSTRATION OF CLAD YTTRIUM HYDRIDE AS A NEUTRON MODERATOR. J. C. Marshall, R. Van Houten, and W. G. Baxter (General Electric Co., Cincinnati). Trans. Am. Nucl. Soc., 7: 123(June 1964).

**28559** OUTPUT SPECTRA OF 14-Mev NEUTRON GENERATORS: RAPID ESTIMATION AND INFLUENCE IN ACTIVATION ANALYSIS. E. Ricci (Oak Ridge National Lab., Eng.). Trans. Am. Nucl. Soc., 7: 203-4(June 1964).

**28560** DAMPING THEORY AND ITS APPLICATION TO THE INTERPRETATION OF SLOW NEUTRON SCATTERING EXPERIMENTS. A. Ziya Akcasu (Univ. of Michigan, Ann Arbor). 70p. (CONF-481-58)

From American Physical Society Annual Meeting, New York, Jan. 1964.

The damping theory, which includes the decay of quantum states, is developed in terms of the projection operators. The concept of probability that a transition from a given initial state will be towards a specified final state is introduced, and the probability is calculated by using the damping theory. When the decay of the final state is neglected, this probability reduces to the conditional probability, introduced by Heitler, that the system will be found in a specified final state after a transition from the given initial state has definitely taken place. With this new probability concept, an approximate expression is obtained for the transition probability per unit time from the initial to the final state. This expression is the starting point of the line shape theory, which is applicable to both neutron and photon spectra. Only the scattering of slow neutrons by an anharmonic crystal is considered. However, the differential scattering cross section formula is obtained first for an arbitrary macroscopic medium, and then applied to a crystal. The cross section formula in the harmonic approximation follows from the cross section formula when the width and shift of lines are neglected. The novel feature of this derivation is that it does not use Bloch's theorem. Explicit formulas for the width and the shift of the observed peaks in the energy spectrum of the inelastically scattered slow neutrons by crystals are obtained, and compared in the case of a single-phonon event to those by Maradudin and Fein. It is found that the shift formulas agree exactly at all temperatures, whereas the width formulas agree only in the zero temperature limit. The discrepancy in the width formulas at finite temperatures is discussed in terms of the concept of phonon lifetime. The application of the present line shape theory to the interpretation of the optical experiments is also discussed. (auth)

## Nuclear Properties and Reactions

*Refer also to abstracts 27793 and 28419.*

**28561** (AE-139) ANGULAR DISTRIBUTIONS OF NEUTRONS FROM (p,n)-REACTIONS IN SOME MIRROR NUCLEI. L. G. Stroemberg, T. Wiedling, and B. Holmqvist (Aktiebolaget Atomenergi, Stockholm). Apr. 1964. 27p.

The angular distributions of neutrons from the reactions $^{13}C(p,n)^{13}N$ and $^{19}F(p,n)^{19}Ne$ were measured for some energies close to the reactions threshold. For the reaction $^{11}B(p,n)^{11}C$, angular distributions were measured at several proton energies below the reaction threshold of the neutrons to the first excited state in $^{11}C$. A 5.5-Mev Van de Graaff was used for the experiments. The neutrons were detected with a longcounter. The measurements were carried out for 16 energies for the $^{11}B(p,n)$ reaction, 3 energies for the $^{13}C(p,n)$ reaction, and for 7 energies for the $^{19}F(p,n)$ reaction. One of the main reasons for investigating these (p,n) reactions was to check whether the direct reaction process is important at low proton energies as well as close to reaction thresholds in nuclei consisting of closed shells of neutrons and protons either with an extra nucleon outside the closed shell or a nucleon hole. 140 references cited. (auth)

**28562** (AE-143) CROSS SECTION MEASUREMENTS FOR SOME ELEMENTS SUITED AS THERMAL SPECTRUM INDICATORS: Cd, Sm, Gd, AND Lu. E. Sokolowski, H. Pekarek, and E. Jonsson (Aktiebolaget Atomenergi, Stockholm). May 1964. 28p.

The effective cross sections of Cd, Sm, Gd, and Lu were measured by the oscillator technique in the spectrum of the central channel of the Swedish reactor R1. For Cd, Sm, and Gd the 2200 m/s cross sections were deduced on the basis of Westcott's g and s factors. The values obtained were generally in agreement with other recent values obtained by integral methods, although a systematic trend indicated that the value $T_n - T_m = 29 \pm 10°C$ for the neutron spectrum, measured with a fast chopper, was slightly too high. A new value of $T_n - T_m = 22.5 \pm 3.5°C$ was deduced and new 2200 m/s cross sections were obtained by iteration. For natural Lu, the energy dependence of the cross section is not well known. Certain assumptions about the cross section function led to unreasonably high values for the 2200 m/s cross section. Complementary differential measurements of the cross sections of Cd, Sm, and Gd were made with the R1 fast chopper. For Cd and Sm, the 2200 m/s cross section thus obtained agreed within experimental error with those obtained from the integral measurements. For Gd, the chopper measured value was higher, confirming earlier findings and indicating that the Westcott g factor for Gd is too high. (auth)

**28563** (BNL-7982) FINAL-STATE INTERACTIONS IN FEW-NUCLEON SYSTEMS. P. F. Donovan, J. V. Kane (Bell Telephone Labs., Inc., Murray Hill, N. J.; Brookhaven National Lab., Upton, N. Y.); J. F. Mollenauer (Brookhaven National Lab., Upton, N. Y.); and C. Zupancic (Ljubljana, Yugoslavia. Univerza). [nd]. Contract AT-30-2-GEN-16. 6p. (CONF-502-10)

From International Congress of Nuclear Physics, Paris, July 1964.

The reaction p(D,2p)n was investigated using 21.1-Mev deuterons. The protons were detected in coincidence by semiconductor particle detectors, and the energy correlations recorded by an on-line SDS-910 computer system. Final-state interactions were observed as peaks in the cross section at energies near the breakup threshold in the intermediate (n+p) systems. A peak was also seen at higher energy in the intermediate (p+p) system. A similar investigation of the reaction D(D,Dp)n, where the formation of the singlet two-nucleon systems is forbidden by isospin conservation, nevertheless showed a strong energy cor-

relation under conditions where the recoil neutron had a very low laboratory energy. (auth)

**28564** (CONF-446-5) A MEASUREMENT OF $\alpha$ FOR U-235 IN THE EPITHERMAL REGION. L. J. Esch, F. Feiner, J. L. Mewherter, A. F. Heitcamp, and H. M. Eiland (Knolls Atomic Power Lab., Schenectady, N. Y.). [1963]. Contract [W-31-109-eng-52]. 12p.

From the American Nuclear Society 10th Annual Meeting, Philadelphia, June 1964.

The accurate integral measurement of $\alpha$, the capture-to-fission ratio, for $^{235}U$ was experimentally determined for samples containing only 0.095 ppm $^{236}U$. (R.E.U.)

**28565** (COO-1195-12) PRODUCTION OF $^{7}Be$ FROM $^{9}Be$, $^{12}C$ AND $^{16}O$ BY HIGH ENERGY PHOTONS. B. M. K. Nefkens, G. Moscati, and J. Todoroff (Illinois. Univ., Urbana). [1964]. Contract AT(11-1)-1195. 31p.

The production of $^{7}Be$ from $^{9}Be$, $^{12}C$, and $^{16}O$ by 45 to 275 Mev bremsstrahlung was measured by the residual activity method. The cross sections for the production of $^{7}Be$ from $^{9}Be$ and $^{12}C$ each have two maxima that are of comparable size. The first maximum occurs at the tail of the giant resonance and the second maximum close to meson threshold. The integrated cross sections from threshold to 275 Mev are 10 Mev-mb for $^{9}Be$ and 13 Mev-mb for $^{12}C$. The production cross section for $^{16}O \rightarrow {}^{7}Be$ is $\sigma_p = 0.03$ mb. The cross sections are normalized to the $^{12}C(\gamma,n)^{11}C$ cross section. (auth)

**28566** (IAN-F-1) SECCION EFICAZ PARA LA REACCION $Au^{197}(d,p)Au^{198}$. (Cross Section for the $Au^{197}(d,p)Au^{198}$ Reaction). E. Sandoval and E. Paez (Colombia. Instituto de Asuntos Nucleares, Bogotá). Nov. 1963. 13p.

The cross section for the $^{197}Au(d,p)^{198}Au$ reaction was determined experimentally for incident deuterons in the energy range 5.6 to 28 Mev, using the "stacked foil" technique. A theoretical confirmation was undertaken following the treatment. The maximum cross section was found to lie between 14 and 15 Mev, with value of 290 mb. The irradiation was accomplished in the 71-inch synchrocyclotron of the Argentinian Atomic Energy Commission. (auth)

**28567** (JINR-D-1570) ON THE PROTON DECAY OF RADIOACTIVE NUCLEI. G. N. Flerov, V. A. Karnaukhov, G. M. Ter-Akopyan, L. A. Petrov, and V. G. Subbotin (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Reactions). 1964. 25p.

Some experiments on proton decay are described. The data on two proton emitters detected in the exposure of Ni to $^{20}Ne$ and $^{16}O$ beams are listed. The first emitter (a Ne or Mg isotope) has a lifetime of $(85 \pm 15)\ 10^{-3}$ sec and emits protons with an energy of $5 \pm 0.2$ Mev, while the second one, having a $(23 \pm 4)-$sec lifetime, emits protons with an energy of $2.5 \pm 0.2$ Mev. It is concluded that the second emitter is a Br of Kr isotope. In this case subbarrier proton emission takes place (the Coulomb barrier height is about 8.5 Mev). It is most probable that protons are emitted from a daughter nucleus after positron transition with which the half life under measurement is associated. The process of proton emission with $E_p = 5$ Mev is similar to that for delayed neutron emission. The mechanism of subbarrier proton emission with $E_p = 2.5$ Mev is analogous to that for long-range alpha emission by heavy nuclei. The possibility of configuration isomer proton decay which is not excluded in the case of a 2.5-Mev proton emitter, is also considered. (auth)

**28568** (JINR-E-1621) ENERGIES OF THE EXCITED STATES OF SOME EVEN STRONGLY DEFORMED NUCLEI IN THE RANGE $164 \leq A < 190$. N. I. Pyatov and V. G. Soloviev (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). 1964. 23p.

The two-quasiparticle excitations for $^{164}Dy$, $^{164}Er$, $^{168}Yb$, $^{174}Yb$, $^{176}Hf$, $^{184}W$, and $^{186}Os$ were calculated using the nuclear superfluid model. The energies of the quadrupole and octupole collective states are given. Several beta decay schemes are analyzed. The splitting energies of some two-quasiparticle states are estimated. (auth)

**28569** (MITNE-37) MEASUREMENT OF GAMMA-RAY SPECTRA FROM THERMAL-NEUTRON CAPTURE. Scientific Report No. 1. John M. Neill, Norman C. Rasmussen, and Theos J. Thompson (Massachusetts Inst. of Tech., Cambridge). Aug. 1963. Contract AF19(604)-7492. 171p. (AD-428231; AFCRL-63-341)

Thesis by John M. Neill.

An investigation of the gamma spectra of several isotopes from thermal-neutron capture was carried out. The isotopes irradiated were $^{45}Sc$, $^{191}Ir$, $^{193}Ir$, $^{103}Rh$, $^{161}Dy$, $^{164}Dy$, and $^{165}Ho$. The technique of using the bent crystal spectrometer was refined by means of improved development of the photographic emulsion used as a detector, by means of a formalized data-taking procedure and by the use of a digital computer to analyze the results in a consistent fashion. The instrument was used to survey the low-energy photons from neutron capture by natural scandium, iridium, and rhodium. A scintillation pair spectrometer is coupled to a two-parameter analyzer and was used in coincidence studies of neutron-capture gamma rays from $^{161}Dy$, $^{164}Dy$, and $^{165}Ho$. Its operation was aided by the use of a digital computer to perform data reduction. An attempt was made to perform stripping on the complex gamma spectra obtained. The results were compiled and nuclear energy level schemes were proposed for $^{46}Sc$ and somewhat tentatively for $^{165}Dy$ and $^{166}Ho$. Possible additions to the present nuclear energy level schemes of $^{104}Rh$ and $^{162}Dy$ are also presented. (auth)

**28570** (NP-13995) SPALTAUSBEUTEN DER JODISOTOPE 131 BIS 135 BEI DER SPONTANEN SPALTUNG VON NATURLICHEM URAN (THESE). (Fission Yields of the Iodine Isotopes 131 to 135 in the Spontaneous Fission of Natural Uranium (thesis)). Helmut Menke (Johannes-Gutenberg-Universität, Mainz). 1963. 118p.

The cumulative fission yields of iodine isotopes with masses 131, 132, 133, 134, and 135 from the spontaneous fission of natural uranium were determined. The fission products were separated from a hydrochloric acid solution of uranyl chloride. The exchange between $IO_4^-$ added as a carrier and the radioiodine was brought about by reduction to $I^-$ with $SO_2$ and then oxidation to $I_2$ with $Na_2Cr_2O_7$ solution. A 100% exchange under these conditions was assumed. The iodine was extracted from the uranium solution with carbon tetrachloride and back-extracted with a $Na_2SO_3$ solution. Radiochemical purification was carried out by distillation. The decay curves were analyzed by graphs and calculations. Average values were obtained for calculated that in spontaneous fission of $^{238}U$ mass yields are more asymmetrical than in the induced fission of $^{235}U$. (M.C.G.)

**28571** (NP-13996) UNTERSUCHUNGEN ZUM ZERFALL DER ANTIMONISOMEREN-126, 128, 130 UND ZUR UNABHANGIGEN SPALTAUSBEUTE VON ANTIMON-124 UND 126 BEI DER SPALTUNG VON URAN-235 MIT THERMISCHEN NEUTRONEN (THESE). (Study on the Decay of Antimony Isomers 126, 128, 130, and the Independent Fission Yield of Antimony-124 and 126 in the

Fission of Uranium-235 with Thermal Neutrons (thesis)). Gerald Lange (Johannes-Gutenberg-Universitat, Mainz). 1963. 153p.

From highly excited tellurium isotopes with mass numbers 126, 128, and 130, antimony isotopes of the same mass number were prepared with 14-Mev neutrons by (n,p) reactions. The decay of the antimony isotopes was investigated. Two isomers were found to exist for each of the three isotopes. Measurements of half life gave: 19.0 ± 0.1 min and 12.4 ± 0.3 days for $^{126}$Sb; 10.5 ± 0.3 min and 9.3 ± 0.2 hr for $^{128}$Sb; and 5.7 ± 1.0 and 38 ± 3 min for $^{130}$Sb. Gamma spectra were measured and compared with values obtained by other authors. The beta spectra of the 19 min $^{126}$Sb, 10.5 min $^{128}$Sb, and 9.3 hr $^{128}$Sb were also measured. From the $^{124}$Sb and 12.4 day $^{126}$Sb the independent fission yields of $^{235}$U fission by thermal neutrons were measured. (tr-auth)

**28572** (ORNL-3615) THE YIELD OF ELASTICALLY SCATTERED 17- TO 21-Mev NEUTRONS FROM THE REACTION $C^{12}(n,n)C^{12}$. Marvin Vernon Harlow, Jr. (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 117p.

Thesis submitted to Univ. of Texas, Austin.

A search was made for a neutron resonance at 22.7-Mev excitation in $^{13}$C, which would be formed by a 19.3-Mev neutron plus $^{12}$C. The experimental procedure and results for differential cross section measurements are presented. The total cross sections were also calculated. (R.E.U.)

**28573** (ORNL-3630(p.1-17)) HEAVY-PARTICLE PHYSICS. A. Zucker, K. S. Toth, M. L. Halbert, C. D. Moak, E. Newman, H. F. Bowsher, F. E. Durham, I. R. Williams, J. R. Donaldson, and C. B. Hose (Oak Ridge National Lab., Tenn.).

In the heavy-ion nuclear physics program, use was made of the oxygen and nitrogen beams from the Tandem Van de Graaff and, to a limited extent, nitrogen ions from the ORNL 63-Inch Cyclotron. Statistical fluctuations in the differential and total cross section of the reaction $^{12}C(^{16}O,\alpha)^{24}Mg$ were investigated. Excitation functions for several nucleon transfer reactions were measured, and angular distributions for one of them were determined at three energies near the Coulomb barrier. Excitation functions for reactions of nitrogen on lithium indicate a high cross section for direct processes. The work on determination of the spin-cutoff parameter from compound-nucleus reactions was extended by means of a complete quantum-mechanical calculation. (auth)

**28574** (ORNL-3630(p.18-30)) PHYSICS RESEARCH WITH 22-Mev PROTONS. C. D. Goodman, J. B. Ball, C. B. Fulmer, B. Harmatz, E. L. Olson, and R. F. Sweet (Oak Ridge National Lab., Tenn.).

The effects of the residual proton-neutron interaction on low-lying levels of $^{92}$Nb from $^{93}$Nb(p,d)$^{92}$Nb were studied; individual levels were resolved and the matrix elements of the residual interaction were evaluated, and a ground-state wave function for $^{93}$Nb was determined. Energy levels of $^{89}$Zr from $^{90}$Zr(p,d)$^{89}$Zr were studied, and wave functions for these and related levels were developed. Nuclear levels of $^{190}$Os populated in the decay of triple isomeric states in $^{190}$Ir were studied, and detailed information is given. Differential cross sections were studied for excitation of the isobaric analog states in $^{45}$Sc(p,n)$^{45}$Ti reactions and (p,n) reactions with the stable isotopes of titanium. The magnet system for analyzing charged particles in the external beam of the ORNL 86-Inch Cyclotron is described. (R.E.U.)

**28575** (ORNL-3630(p.31-7)) THEORETICAL PHYSICS R. H. Bassel, E. C. Halbert, K. H. Bhatt, G. R. Satchler, R. M. Drisko, and S. S. M. Wong (Oak Ridge National Lab., Tenn.).

Calculations are described for determining nuclear properties from the shell model. The results of calculations of the momentum spectra for $\Sigma^-$ reactions with helium-4 [$^4$He($\Sigma^-$,n$\Lambda$)$^3$H] are reported. Optical-model results are given for single excitation of the 4.43-Mev ($2^+$) state in carbon and the 6.14-Mev ($3^-$) state in oxygen in the elastic scattering of 168-Mev oxygen ions from carbon; the collective model is used to explain the $3^-$ state. (R.E.U.)

**28576** (ORNL-3636) KINEMATICS NOMOGRAM FOR LOW-ENERGY NUCLEAR REACTIONS. J. K. Dickens (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 28p.

For given particles a, b in the nuclear two-body reaction X(a,b)Y, the nomogram described solves the nonrelativistic kinematics relation $Q = E_b(1 + M_b/M_Y) - E_a(1 - M_a/M_Y) - 2\cos\theta\,(M_aM_bE_aE_b)^{1/2}/M_Y$ for any one of the variables Q, $E_a$, $E_b$, $\theta$, and $M_Y$ in terms of the others. Nomograms are presented for the reactions (p,p'), (p,d), (p,t), (p,$\alpha$), (d,d), (d,p), ($^3$He,d), ($\alpha$,$\alpha$), ($\alpha$,p), ($^{16}$O,$^{16}$O), and ($^{16}$O,$\alpha$), and the FORTRAN program used to plot them is included. (auth)

**28577** (ORNL-3637) ELASTIC AND INELASTIC SCATTERING OF 5- TO 13.5-Mev DEUTERONS FROM $Ni^{60}$: TABULATED DIFFERENTIAL CROSS SECTIONS. J. K. Dickens and F. G. Perey (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 18p.

Angular distributions for elastic scattering of deuterons from $^{60}$Ni were measured for incident deuteron energies of 4.86, 5.86, 6.87, 7.88, 8.88, 9.89, 10.86, 11.92, and 13.56 Mev. Differential cross sections were obtained at 5° intervals between laboratory angles of 30 and 160°. Cross sections for deuterons inelastically scattered from the first excited state of $^{60}$Ni (Q = −1.33 Mev) were obtained for the four incident deuteron energies between 9.89 and 13.56 Mev. Numerical values for all measured cross sections are tabulated. (auth)

**28578** (ORNL-3638) MEASUREMENT AND SHELL MODEL INTERPRETATION OF THE LOW-LYING NUCLEAR ENERGY LEVELS OF NIOBIUM-92 (thesis). R. F. Sweet (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 103p.

Submitted to Univ. of Texas.

Experimental information is used to characterize the residual interaction of a nucleon with all the other nuclear particles, which cannot be replaced by an average central field, in the jj-coupling nuclear shell model. $^{92}$Nb was chosen to study the neutron-proton residual interaction. The experimental procedures and data, and theoretical interpretations are given. (R.E.U.)

**28579** (TID-20689) GAMMA RAY PRODUCTION CROSS SECTIONS FOR 4.0-Mev AND 14.8-Mev NEUTRONS. Summary Technical Report, December 15, 1960–December 14, 1961. D. O. Nellis, R. W. Benjamin, J. B. Ashe, J. T. Prud'homme, and I. L. Morgan (Texas Nuclear Corp., Austin, Tex.). Feb. 22, 1962. Contract AT(40-1)-2791. 82p.

Relative gamma production cross sections for the reactions of 4.0-Mev neutrons in Al, Fe, Ni, Zr, W, Pb, $^{206}$Pb, $^{207}$Pb, and 14.8-Mev neutrons in C, Fe, Ni, Zr, W, Pb, $^{206+}$Pb, and $^{208+}$Pb were measured. The absolute gamma production cross sections have been computed and tabulated. Measurements were made at an angle of 90° to the incident neutron beam. The gamma detector consisted of a central NaI(Tl) detecting crystal in an annular NaI(Tl)

anti-coincidence crystal. Swept beam time-of-flight techniques were employed to reduce neutron and time-random backgrounds. A description of the experimental apparatus and an outline of the techniques used to determine neutron fluxes and absolute cross sections are included. (auth)

**28580** (WAPD-BT-30(p.47-52)) RECOIL RANGE OF FISSION FRAGMENTS. P. W. Frank (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh).

Empirical equations are presented for calculating the range of fission fragments from the thermal-neutron-induced fission of uranium-235 in any material. The average uncertainty is approximately 2 percent, excluding the very light gases that have a high uncertainty. (auth)

**28581** (FTD-TT-63-991) REACTION OF $He^3$ WITH DEUTERONS. A. P. Klyucharev, A. K. Val'ter, and B. N. Yesel'sov. Translated from Tr. Sessii Akad. Nauk, Ukr, SSR po Mirnomu Ispol'z. At. Energ., 64-9(1958). 10p.

The cross sections for $^3He(d,p)^4He$ were investigated at deuteron energies of 100 to 1500 kev by alpha particle detection. (R.E.U.)

**28582** (ORNL-tr-190) INTERNAL CONVERSION ELECTRON SPECTRA OF $Pm^{151} \rightarrow Sm^{151}$ DECAY. Georges Marquier and Andree Juillard. Translated by P. L. Moore (Oak Ridge National Lab., Tenn.), from Compt. Rend., 256: 3053(1963). 4p.

Spectra were obtained using an iron-free, double-focusing beta spectrometer. The resolving power ranged from 3 to $6 \times 10^{-3}$ for intense and weak rays. Previously unreported transitions of 25.65, 35.04, 38.09, 76.17, 101.9, 156.2, 162.82, 167.94, 227.8, and 236.9 kev were observed. The transition energies, relative intensities, conversion coefficients, and polarities obtained from the data are included. (D.C.W.)

**28583** KINEMATICAL PROPERTIES OF DEFORMED NUCLEI AND THE HILL-WHEELER INTEGRALS. II. THE E2 MOMENT AND GAMMA TRANSITIONS WITHIN A BAND. Han-chou Liu (Nankai Univ., Tientsin, China). Acta Phys. Polon., 25: 305-11(Mar. 1964).

General formulas for the electric quadrupole moment and the electromagnetic transition probabilities within a rotational band were derived for deformed, intermediate and heavy nuclei by means of wave functions generated from the Hill-Wheeler integrals. Numerical calculations showed that the formulas for electric quadrupole moment and E2 transition probability are practically equivalent to the corresponding ones of the rotational model. The formula for M1 transition probability differed from that of the rotational model only in the explicit expression of the $g_R$ factor, which was the same as in the magnetic dipole moment. (auth)

**28584** THE MEAN NUMBER OF CONVERSION ELECTRONS PER ONE DECAY OF $Tm^{165}$. S. Chojnacki, I. Jarosiewicz, Z. Preibisz, and J. Zylicz (Inst. for Nuclear Research, Swierk, Poland). Acta Phys. Polon., 25: 417-25(Mar. 1964).

A simple method of determining the mean number of internal conversion electrons per one decay of $^{165}Tm$ was applied. The measurements were carried out with magnetic beta spectrometers and scintillation techniques. The result for the K conversion line of the 807-kev transition was $(7.8 \pm 0.8) \times 10^{-4}$ electrons per one decay. Also, the half life of $Tm^{165}$ was determined as $T_{\frac{1}{2}} = (29.6 \pm 0.5)$ hr. The number of electrons per one decay for other transitions following $^{165}Tm \rightarrow {}^{165}Er$ decay could be determined from the data concerning the relative intensities of conversion lines established by other authors. The results obtained were used in a discussion of the possible three-quasiparticle nature of the 1427-kev level in $^{165}Er$. (auth)

**28585** THEORETICAL ANALYSIS OF THE ELASTIC SCATTERING $^{16}O(d,d)^{16}O$ ACCORDING TO THE OPTICAL MODEL. A. García, E. A. King, and R. Díez (Oxford Univ. and Centro de Fisica Fotocorpuscular, Facultad de Ciencias, Valencia). Anales Real Soc. Espan. Fis. Quim. (Madrid), Ser. A, 59: 173-8(Sept.-Oct. 1963). (In Spanish)

The $^{16}O(d,d)^{16}O$ elastic scattering was studied at bombarding energies of 8.0 to 10.5 Mev with a 24-channel magnetic spectrograph. Differential cross sections over the range 12°30′ to 175° were measured. Experimental results were compared with several calculations based on the optical model of the interaction. (auth)

**28586** TOTAL CROSS SECTION OF NEODYMIUM FOR FAST NEUTRONS. F. Manero (Junta de Energia Nuclear, Madrid). Anales Real Soc. Espan. Fis. Quim. (Madrid), Ser. A, 59: 179-86(Sept.-Oct. 1963). (In Spanish)

The total neutron cross sections of neodymium were measured in the energy range of 3.3 to 5.0 Mev. The measurements were made in a good geometry and with a total neutron energy spread of about ±30 kev. The neutrons were produced by bombarding a thin heavy ice target with deuterons. The neutron cross sections of neodymium were obtained by subtracting the oxygen total cross sections from the measured $Nd_2O_3$ cross sections. (auth)

**28587** PLANE-WAVE APPROXIMATION FOR THE SCATTERING AMPLITUDE. H. H. Chan and M. Razavy (Univ. of Alberta, Edmonton, Can.). Can. J. Phys., 42: 1017-29(June 1964).

Different methods of calculating the s-wave scattering amplitude using the plane-wave approximation are discussed. The resulting scattering amplitudes satisfy the unitarity condition and for high energies approach the Born approximation asymptotically. These methods are applied to the special class of potentials that can be expressed as an infinite sum of exponential potentials, and in particular to some potentials for which the exact solutions are known. It is found that imposing the unitarity condition on the Born approximation, in general, does not improve the result of the calculation. (auth)

**28588** EXCITATION CURVES FOR THE REACTIONS $Fe^{56}(n,p)Mn^{56}$ AND $Co^{59}(n,\alpha)Mn^{56}$. D. C. Santry and J. P. Butler (Atomic Energy of Canada Ltd., Chalk River, Ont., Can.). Can. J. Phys., 42: 1030-6(June 1964). (AECL-1935)

The excitation curves for the reactions $^{56}Fe(n,p)^{56}Mn$ and $^{59}Co(n,\alpha)^{56}Mn$ were measured by the activation method from near threshold energies to 20.3 Mev. The measurements are relative to the known cross section for the $^{32}S(n,p)^{32}P$ reaction. The cross sections for both reactions increase smoothly with neutron energy and reach maximum values of 119 ± 4 mb for the $^{56}Fe(n,p)$ reaction at 13.6 Mev and 30.0 ± 0.9 mb for the $^{59}Co(n,\alpha)$ reaction at 14.5 Mev. Above 15 Mev both cross sections decrease with neutron energy. From the excitation curves effective cross-section values for a fission-neutron spectrum were calculated as 1.04 ± 0.05 mb for the (n,p) reaction and 0.140 ± 0.007 mb for the $(n,\alpha)$ reaction. (auth)

**28589** NEUTRON SPECTRUM OF A Ra–Be$(\alpha,n)$ SOURCE. K. W. Geiger, R. Hum, and C. J. D. Jarvis (National Research Council of Canada, Ottawa). Can. J. Phys., 42: 1097-1100(June 1964). (NRC-7901)

The neutron energy spectrum of a Ra–Be source was measured successfully by the nuclear emulsion technique

without introducing a significant thickness of lead absorber to reduce the gamma background. In comparison with spectra in the literature, the part of the spectrum below 4 Mev is found to be somewhat less intense, probably due to the absence of inelastic scattering in the lead. No observations could be made below 0.75 Mev; however, by comparison with the source emission rate, it was estimated that this fraction of the spectrum contributes (37 ± 15)% of the total neutron emission. (auth)

**28590** THE MEASUREMENT AND ANALYSIS OF TRIPLE CORRELATIONS. Philip B. Smith (Universiteit, Groningen, Netherlands). Can. J. Phys., 42: 1101-15 (June 1964).

The measurement and analysis of the intensity-direction correlation of gamma rays emitted in cascade following heavy-particle capture are treated. A procedure is discussed which is based upon the expansion of the triple-correlation intensity in terms of the set of angular functions orthogonal over the space of the emission (or absorption) directions. In the analysis procedure proposed, the population parameters are found directly from the originai data, with the gamma-radiation mixing ratios assigned. The least-squares equations representing the best fit to the data contain the population parameters linearly and are solved by a standard computer program which also gives the values of $\chi^2$. The true solution is then found by varying the mixing ratios until a minimum in $\chi^2$ is reached. In addition to the determination of the population parameters of the decaying state and the mixing ratios of the gamma rays in the cascade, the calculation of the error matrix of these quantities and of the formation parameters in simple capture are described. (auth)

**28591** GAMMA-RAY ANGULAR CORRELATION MEASUREMENTS IN $Ne^{22}$. C. Broude and M. A. Eswaran (Chalk River Nuclear Labs., Chalk River, Ont., Can.). Can. J. Phys., 42: 1300-10(June 1964). (AECL-1958)

Coincidence gamma angular correlations of the cascade decays from the 3.34- and 4.47-Mev states in $^{22}Ne$ through the first excited state were measured. The levels were excited by the reaction $^{19}F(\alpha,p)^{22}Ne$. The correlations give an unambiguous spin assignment of 4 to the 3.34-Mev state; the analysis of the correlations from the 4.47-Mev state is not unique, allowing spin 2 or 3. The quadrupole-to-dipole amplitude ratio for the primary radiation is −0.11 ± 0.03 or −1.07 ± 0.10, respectively, for the spin-2 and spin-3 assignments. (auth)

**28592** LIFETIME MEASUREMENTS OF STATES IN $O^{18}$ AND $Ne^{22}$. M. A. Eswaran and C. Broude (Chalk River Nuclear Labs., Chalk River, Ont., Can.). Can. J. Phys., 42: 1311-23(June 1964). (AECL-1959)

Lifetime measurements were made by the Doppler-shift attenuation method for the 1.98-, 3.63-, 3.92-, and 4.45-Mev states in $^{18}O$ and the 1.28-, 3.34-, and 4.47-Mev states in $^{22}Ne$ excited by the reactions $^{7}Li(^{12}C,p\gamma)^{18}O$ and $^{7}Li(^{18}O,p\gamma)^{22}Ne$. Branching ratios were also measured. The results are tabulated. The decay of the 3.92-Mev state in $^{18}O$ is 93.5% to the 1.98-Mev state and 6.5% to the ground state — of the 4.45-Mev state, 74% to the 3.63-Mev state, 26% to the 1.98-Mev state, and less than 2% to the ground state. In $^{22}Ne$, the ground-state transition from the 4.47-Mev state is less than 2% of the decay to the first excited state. (auth)

**28593** STUDY AND INFLUENCE OF THE SECOND TERM OF THE BORN SERIES ON THE EFFECTIVE DIFFERENTIAL CROSS SECTION FOR STRIPPING. Jacques Pigeon, Edgard El-Baz, and Joseph Lafoucriere (Institut de Physique Nucleaire, Lyon). Compt. Rend., 258: 3970-3 (Apr. 20, 1964). (In French)

The influence of the second term of the Born series was studied in the plane wave approximation. This influence is exerted mainly at large angles and eliminates the zeros of the principal term. (tr-auth)

**28594** STUDY OF THE STRUCTURE OF SOME $He^3$ LEVELS EXCITED BY ELECTRON BOMBARDMENT. Jean-Pierre Descoubes, Bernard Decomps, and Jean Brossel (Laboratoire de Physique E.N.S., Paris). Comp. Rend., 258: 4005-8(Apr. 20, 1964). (In French)

The hyperfine structure of the $^1D$ levels of $^3He$ excited by electron impact was determined by magnetic resonance. The results show the existence of a configuration interaction between the $n^1D_2$ and $n^3D_2$ levels. (tr-auth)

**28595** NUCLEONIC POLARIZATION OF 424-Mev PROTONS BY CARBON. G. Z. Shah and B. M. Thaker (Bhavan's Coll., Bombay). Current Sci. (India), 31: 142 (Apr. 1962).

A theoretical interpretation is applied to the experimental observations by Heiberg on the nucleonic polarization for the elastic scattering of 424-Mev protons by C. Assuming the validity of the first Born approximation for the nuclear scattering of such high-energy protons, an expression for the nucleonic polarization (P ($\bar{S}$)) was derived. Theoretical values of P ($\bar{S}$) were plotted along with the experimental values of P ($\bar{S}$) obtained by Heiberg. The close agreement obtained between the theoretical and experimental values of P ($\bar{S}$) strengthens the validity of the concept of the characteristic nuclear density distribution. (BBB)

**28596** REMARKS ON K-CONVERSION COEFFICIENTS OF E2 TRANSITIONS IN RARE-EARTH NUCLEI. M. K. Ramaswamy and S. M. Brahmavar (Karnatak Univ., Dharwar, India). Current Sci. (India), 32: 451(Oct. 1963).

Previous studies on E2 transitions in rare-earth nuclei indicated a correlation between nuclear deformation and deviations in $\alpha K$ from theory. This was concluded in spite of the large errors in the available experimental data for E2 conversion coefficients. It is shown that more accurate values for E2 transitions can be obtained for comparison with theory by combining the data on measured half-life, the reduced E2 transition probabilities determined by inelastic proton scattering, and measured energies, which are related by an equation from which $\alpha K$ can be calculated. This value can be in turn compared with a direct determination of $\alpha K$ by magnetic spectrometry. Such a comparison is made for data available for $^{152}Sm$, $^{154}Gd$, $^{156}Gd$, $^{160}Dy$, $^{164}Er$, $^{166}Er$, $^{170}Yb$, and $^{182}W$. Comparison of these results show that $\alpha K$ determined from the equation given has a smaller error than the weighted values of $\alpha K$ determined directly. The two values of $\alpha K$ agree closely except possibly in the case of the 123-kev transition in $^{154}Gd$, indicating the necessity of remeasurement of one of the variables used in the equation for calculating $\alpha K$. $\alpha K$ values measured by the internal-external conversion method are the most accurate and give a precision of 3% or better, but the described calculation may provide a check on this method. (BBB)

**28597** NUCLEAR CORE ISOMERISM: AN EMPIRICAL APPROACH BASED ON TRANSITION PROBABILITIES. S. M. Brahmavar and M. K. Ramaswamy (Karnatak Univ., Dharwar, India). Indian J. Pure Appl. Phys., 2: 170-2 (May 1964).

An empirical approach to the problem of nuclear core isomerism is made on the basis of transition probability. Various probable couplings for core + odd particle result

in a possible second isomeric state in $^{93}$Mo. The possibility of additional new core isomers is indicated. (auth)

**28598** THE PROBABILITIES OF FIRST-FORBIDDEN MAGNETIC DIPOLE TRANSITIONS IN NUCLEI. E. E. Berlovich and G. M. Bukat. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 214-21(Feb. 1964). (In Russian)

The nature of first-forbidden transitions was clarified by proper selection of the available experimental material. M1 transitions in $^{63}$Cu, $^{57}$Fe, $^{107}$Ag, $^{109}$Ag, etc., were omitted as were other doubtful cases. The proton transition $5/2^- \rightarrow 3/2^-$ was considered for $^{75}$As. Proton transitions of the type $1g(7/2) \rightleftharpoons 2d(5/2)$ are compiled for $^{129,131}$I, $^{131,133,135}$Cs, $^{137,139}$La, $^{141,143}$Pr, $^{145,147}$Pm, and $^{147,149,151}$Eu. Proton transitions of the type $2d(3/2) \rightleftharpoons 3s(1/2)$ are considered for $^{191,193}$Ir, $^{193,195,197}$Au, and $^{201,203,205}$Tl. Neutron transitions of the type $2d(3/2) \rightleftharpoons 3s(1/2)$ are given for $^{111,113}$Cd, $^{117,119}$Sn, $^{123,125}$Te, and $^{129,131}$Xe. The tables list the nucleus in which the transition takes place, the transition energy $E_\gamma$, the spins and parities of the initial ($I_i^{\pi_i}$) and final ($I_f^{\pi_f}$) states of the nucleus, the radiation lifetime $\tau_\gamma$ of the level with respect to an M1 transition, the delay factor $F_s = \tau_\gamma/\tau_m$, where $\tau_m$ is a calculated lifetime from a single-particle formula, the square of the experimental matrix element $m^2_{exp}$ and the square of the calculated matrix element $m^2_{calc}$, L or U type of transition (L is a transition of a particle from a shell with an odd number of nucleons to a shell with an even number of nucleons, and the opposite is a U type of transition), and finally, the proton and neutron configurations for the final state (the configuration for the initial state can be determined from the type of transition). The matrix element ($m^2_{exp}$) is plotted as a function of the mass number. The minimum value of the matrix element $m^2_{exp}$ occurs in the region of a filled neutron shell with n = 82 ($^{137}$La, $^{139}$La, and $^{141}$Pr). With $^{191,193}$Ir, $^{193,195,197}$Au, and $^{201,203,205}$Tl, simultaneous filling of a proton and a neutron shell (z = 82, n = 126) takes place. The value of the matrix element $m^2_{exp}$ is small (0.01 to 0.06). The single-particle approximation is valid in this region. The delay factor $F_s$ varies within the wide limits of ~100 to 3300 for all the proton transitions. (TTT)

**28599** THE $\gamma$-EMISSION OF As$^{76}$. V. D. Vitman, N. A. Voinova, and B. S. Dzhelepov (Mendeleev Research Inst. of Metrology, Academy of Sciences, USSR and Ioffe Inst. of Physics and Tech., Leningrad). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 222-6(Feb. 1964). (In Russian)

The study was carried out to obtain accurate data on the relative intensities of $^{76}$As $\gamma$ lines and to find weak $\gamma$ lines not observed before. A strong source of 20 to 40 curies of $^{76}$As was prepared by irradiating As metal in a flux of (3 to 7) $\times 10^{13}$ neutrons cm$^{-2}$ sec$^{-1}$. A high-activity source is required because the $\gamma$ rays are analyzed by the recoil electrons knocked out of a thin plastic membrane by the $\gamma$ rays, and the efficiency of this process is low. The relative intensities and gamma energies are tabulated and compared with other literature sources. The $\gamma$-energy values agree well with the data of Bäckström and Marklund. A new excitation level with an energy of 2098 kev is proposed for $^{76}$Se. A number of weaker $\gamma$ lines were detected that could not be put in the decay scheme proposed by Bäckström and Marklund. (TTT)

**28600** GAMMA-EMISSION IN THE Ag$^{109}$(n,$\gamma$)Ag$^{110}$ REACTION. L. F. Kalinkin, I. V. Estulin, and A. S. Melioranskii (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 227-8(Feb. 1964). (In Russian)

An enriched target of metallic silver containing 98.8% $^{109}$Ag was used to investigate the $\gamma$ emission from the $^{109}$Ag(n,$\gamma$)$^{110}$Ag reaction by luminescence spectrometry. The NaI(Tl) crystals were 10, 20, and 40 mm high. Pb filters were used to cover the entire energy range of $\gamma$ quanta to 700 kev. The most intensive peaks had energies of 75, 114, and 197 kev. Measurements of the $\gamma\gamma$ coincidences showed that these peaks could be each resolved into at least two $\gamma$ lines: 73 + 84 (75 kev), 105 + 118 (114 kev), and 192 + 212 (197 kev). The intensities of all $\gamma$ transitions observed are given in percent per captured neutron. The $\gamma\gamma$ coincidences were analyzed to determine the $\gamma$-radiation spectrum, but the $\gamma\gamma$ cascades did not show $\gamma$ quanta with the intensities found on the NaI crystal. The lower levels of $^{110}$Ag are not reliably known, and more data will have to be accumulated to determine the decay scheme of $^{110}$Ag. (TTT)

**28601** DOUBLE COULOMB EXCITATION OF THE 4$^+$ LEVELS IN NON-SPHERICAL EVEN-EVEN NUCLEI. D. G. Alkhazov, V. D. Vasil'ev, Yu. P. Gangrskii, and I. Kh. Lemberg. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 229-31 (Feb. 1964). (In Russian)

The cross section for double coulomb excitation increases with increasing energy and charge of the bombarding particle. At low energies of the bombarding particle, the excitation probability of the first 2$^+$ level ($p_{0\rightarrow 2}$) can be calculated. Targets enriched in $^{152}$Sm, $^{154}$Sm, $^{154}$Gd, $^{156}$Gd, $^{158}$Gd, $^{180}$Hf, $^{182}$W, $^{184}$W, and $^{186}$W were bombarded with 37-Mev $^{14}$N ions. The coincidences of the inelastically scattered $^{14}$N ions and the $\gamma$ quanta emitted as a result of coulomb excitation were determined. Two $\gamma$ lines are clearly evident in the coincidence spectrum. One line is associated with the excitation of the first level, and the other line is associated with the cascade excitation of the 4$^+$ level. Values of B(E2, 2 $\rightarrow$ 4) can be obtained from the ratio of the yields associated with excitation of the first and second levels. The value of B(E2, 2 $\rightarrow$ 4) were found to be 1.37 for $^{152}$Sm, 2.32 for $^{154}$Sm, 1.43 for $^{154}$Gd, 2.58 for $^{156}$Gd, 2.96 for $^{158}$Gd, 2.10 for $^{180}$Hf, 2.14 for $^{182}$W, 1.58 for $^{184}$W, and 1.32 e$^2 \times 10^{-48}$ cm$^4$ for $^{186}$W. The energy of the 4$^+$ level ($\Delta E_{0\rightarrow 4}$) and the lifetime of the level ($\tau$) were also computed. It follows from the collective model that the ratio B(E2, 4 $\rightarrow$ 2)/B(E2, 2 $\rightarrow$ 0) = 1.43. This value is found to be valid for the majority of the nuclides with the exception of $^{152}$Sm, $^{154}$Gd, and $^{186}$W, which show a value lower than 1.43. (TTT)

**28602** COULOMB EXCITATION OF ELECTRIC OCTUPOLE TRANSITIONS IN EVEN-EVEN TIN ISOTOPES. D. G. Alkhazov, Yu. P. Gangrskii, I. Kh. Lemberg, and Yu. I. Udralov. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 232-6(Feb. 1964). (In Russian)

Targets enriched in $^{114}$Sn, $^{116}$Sn, $^{118}$Sn, $^{120}$Sn, $^{122}$Sn, and $^{124}$Sn were bombarded with 52.5-Mev $^{14}$N ions. The $\gamma\gamma$ and $\gamma$N coincidences were counted in order to determine the energy of the 3$^-$ level ($\Delta E_{0\rightarrow 3}$), and the energy of the cascade transition between the 3$^-$ and 2$^+$ levels ($\Delta E_{3\rightarrow 2}$). The energy of the collected excited 3$^-$ level increases from 2.28 Mev for $^{114}$Sn to 2.57 Mev for $^{124}$Sn. The value of the reduced transition probability to the 3$^-$ level was calculated from the $\gamma$ intensity observed with the cascade transition from the 3$^-$ level. The values of B(E3, 0 $\rightarrow$ 3) are 0.16 for $^{114}$Sn, 0.22 for $^{116}$Sn, 0.17 for $^{118}$Sn, 0.13 for $^{120}$Sn, 0.21 for $^{122}$Sn, and 0.20 e$^2 \times 10^{-72}$ cm$^6$ for $^{124}$Sn. The ratio of the experimental value of B(E3) to the single-particle calculated value $B(E3)_{sp}$ was within the limits of 20 to 40. This ratio exceeds the ratio $B(E2)/B(E2)_{sp}$ by many fold in the case of the first 2$^+$ levels of the tin isotopes. (TTT)

**28603** THE $\gamma$ EMISSION OF U$^{233}$. I. A. Baranov and A. N. Silant'ev. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 237-8(Feb. 1964). (In Russian)

The $\gamma$ emission of $^{233}U$ was determined by counting $\alpha\gamma$ coincidences. A NaI crystal was used as the $\gamma$ spectrometer, and a gold-silicon semiconductor was used as the $\alpha$ spectrometer. The $^{233}U$ sample with 0.03 $\mu$c of activity on an Al backing was put 1.0 cm from the NaI crystal, and 0.5 cm from the alpha counter. The $\alpha$ counter had an area of 25 $mm^2$ and was made of n-type silicon with a specific resistance of 150 ohm-cm. The resolution of the $\alpha$ spectrometer was 2% with respect to the $^{233}U$ $\alpha$ particles. The $\gamma$ quanta in coincidence with the $^{233}U$ $\alpha$ particles were studied on a multichannel amplitude analyzer. A sum peak corresponding to $\gamma$ rays with energies of 43 and 55 kev and a peak corresponding to a 97-kev $\gamma$ ray were observed. A slight increase above background was observed at 120 kev. The total intensity of the 43- and 55-kev $\gamma$ rays was found to be (0.08 ± 0.02)% per disintegration, and the intensities of the 97- and 125-kev $\gamma$ rays were (0.03 ± 0.01) and (0.005 ± 0.003)%, respectively. The absolute intensities of the 43- and 55-kev $\gamma$ rays can be corrected to 0.07 and 0.01%, respectively. (TTT)

**28604** A STUDY OF THE CONVERSION ELECTRON SPECTRUM OF $Re^{182}$ AND $Re^{182*}$. N. B. Badalov, S. S. Vasilenko, M. G. Kaganskii, and D. L. Kaminskii. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 239-44(Feb. 1964). (In Russian)

A natural tantalum sample was irradiated with 40-Mev $\alpha$ particles from a cyclotron. The rhenium fraction was isolated, and the conversion electrons from the decay of $^{182}Re$ ($T_{½}$ = 13 hrs) and $^{182*}Re$ ($T_{½}$ = 164 hrs) were investigated on a double-focusing spectrometer having a resolution of 0.5%. The assignment of conversion lines to different isomers was made on the basis of half life. The relative intensities were referred to the intensity of the K-conversion line corresponding to 1122-kev $\gamma$ transition being taken as 100. The relative intensities of conversion electrons from the 850- to 1300-kev transitions are in good agreement with the data of Harmatz et al. (Phys. Rev., 112: 1730(1958)). A number of new transitions were detected. Decay schemes are given for $^{182}Re$ and $^{182*}Re$, and spins and parities are proposed for the various excited levels of $^{182}Re$ and $^{182*}Re$. New levels are proposed with energies of 1630, 2147, 2113, and 1865 kev for the decay of $^{182}Re$ ($T_{½}$ = 13 hrs). Transitions with energies of 810 and 895 kev were included in the level scheme of $^{182*}Re$ ($T_{½}$ = 64 hrs). New excited states had to be introduced to take care of 10 new transitions that were detected. (TTT)

**28605** NEW DATA ON THE CONVERSION ELECTRON SPECTRUM OF $Lu^{169+170}$ IN THE ENERGY INTERVAL OF 1040 TO 3250 kev. B. S. Dzhelepov, A. I. Medvedev, I. F. Uchevatkin, and S. A. Shestopalova (Mendeleev Central Research Inst. of Metrology, Academy of Sciences, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 245-51(Feb. 1964). (In Russian)

The conversion electron spectrum of a Lu fraction was taken by means of a double-focusing $\beta$ spectrograph at an angle of $\pi\sqrt{2}$. The isotope assignment was made on the basis of half life. All the conversion lines for $^{169}Lu$ seen by Harmatz et al. (Phys. Rev., 114: 1082(1959) and Phys. Rev., 119: 1345(1960)) were also detected, with the exception of the K 1190.0-kev line. The two sets of data are compared in tabular form. The energies and intensities of the transitions are given. Doubtful lines are listed in a separate table. A number of transitions were identified on a $^{170}Lu$ fraction separated away from a hafnium fraction. (TTT)

**28606** THE DECAY SCHEME OF $Tm^{161}$. A. A. Abdumalikov, A. A. Abdurazakov, and K. Ya. Gromov (Tashkent State Univ., SSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 257-61(Feb. 1964). (In Russian)

A Ta target was irradiated with 660-Mev protons, and a thulium fraction was isolated chromatographically from the rare earth mixture. The conversion electron spectrum within the energy range of 20 to 750 kev was investigated on a $\beta$ spectrograph with a constant magnetic field and a resolution of 0.07%. The experimental intensities of the conversion electron lines of $^{161}Tm$ ($T_{½}$ = 35 min) were compared with the theoretical values for different multipolarities. It was concluded that the 45.6-, 59.5-, and 84.5-kev transitions are mixed (M1 + E2) transitions. The 94.3- and 144.0-kev $\gamma$ transitions have an E2 multipolarity, while the 106.1-, 112.6-, 146.7-, and 172.0-kev transitions are M1. A decay scheme for $^{161}Tm$ is presented with the spins and parities of various levels. It is proposed that the 59.5-kev transition (M1 + E2) is a transition from the $5/2$ ($7/2^-$ [521]) rotational level to the ground state, and that the 84.5 kev (M1 + E2) and 144 kev (E2) transitions are transitions from the $1/2$ ($7/2^-$ [521]) rotational level to the first rotational level and to the ground level of this band. The 172.0-, 250.2-, and 344.7-kev levels belong to a rotational band with a $5/2^-$ [523] state. The relative intensities of $\gamma$ transitions in $^{161}Tm$ and $^{161}Er$ are compared. The log ft value for the 172-kev transition of $^{161}Tm \rightarrow {}^{161}Er$ is greater than seven, and it is a forbidden transition. (TTT)

**28607** THE LOW-LYING LEVELS OF $Al^{27}$. A. K. Val'ter, E. G. Kopanets, A. N. L'vov, and S. P. Tsytko. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 268-70(Feb. 1964). (In Russian)

The low-lying levels of $^{27}Al$ were investigated by studying the resonance in the $^{26}Mg(p,\gamma)^{27}Al$ reaction at a proton energy of 1967 kev. By using a paired scintillation $\gamma$ spectrometer, it was possible to detect $\gamma$ transitions to the ground state and to a number of low-lying $^{27}Al$ levels with excitation energies of 0.84, 1.01, 1.65, and 2.21 Mev. The $\gamma\gamma$ coincidences were also counted to determine the cascade transitions more accurately. A decay scheme is given for the 10.16-Mev resonance state of $^{27}Al$ with estimates of the relative intensities of the $\gamma$ transitions. It is proposed that the spin of the 2.2-Mev excitation level in $^{27}Al$ is $7/2^+$ and that the spins of the 1.65- and 1.83-Mev levels should be less than $7/2$. It is possible that the 1.65- and 1.83-Mev levels form a new band with $K = 1/2$, and hence spins of $1/2$ and $3/2$ can be proposed for these levels. (TTT)

**28608** PROTON CAPTURE BY $Mg^{26}$ AT $E_p$ = 2.0 TO 2.3 Mev. A. K. Val'ter, E. G. Kopanets, A. N. L'vov, and S. P. Tsytko. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 271-4 (Feb. 1964). (In Russian)

A $^{26}Mg$ target was prepared in an electromagnetic separator by penetration of the $^{26}Mg$ ions into a tantalum backing. The $^{26}Mg$ was bombarded with a proton current of about 7 $\mu$amp from an electrostatic generator. The $\gamma$-ray spectrum was studied by means of a scintillation $\gamma$ spectrometer having a NaI(Tl) crystal 70 mm in diameter and 60 mm high. The $\gamma$ transitions between the $^{27}Al$ levels are tabulated for six resonances at $E_p$ = 2015, 2047, 2148, 2183, 2185, and 2221 kev. The relative intensities of the $\gamma$ rays and the asymmetry in the angular distribution of the $\gamma$ rays are also tabulated. Spin values for a number of resonance levels were proposed on the basis of an analysis of the $\gamma$ transitions. The spin for the 10.212-Mev level (resonance at a proton energy $E_p$ = 2015 kev) is equal to $1/2$. The 10.243-Mev level ($E_p$ = 2047 kev) has a spin of $3/2$ or $5/2$. The 10.374-Mev level ($E_p$ = 2183 kev) and 10.376-Mev level ($E_p$ = 2185 kev) have spins of $3/2$ or $1/2$. Decay schemes of the six resonance levels of $^{27}Al$ are given. (TTT)

**28609** A STUDY OF THE FINE AND HYPERFINE STRUCTURE OF NUCLEAR SPECTRA. D. A. Varshalovich. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 275-86(Feb. 1964). (In Russian)

The spectral lines of nuclear radiation have a fine and hyperfine structure with a splitting of $10^{-5}$ to $10^{-7}$ ev, which in many cases is substantially greater than the natural energy width of the line ($\Gamma = \hbar/\tau < 10^{-7}$ ev). However, thermal agitation of the emitting nucleus results in considerable broadening of the line ($\Delta E_\gamma = E_\gamma(v/c)_{nucl.} > 10^{-1}$ ev). Mössbauer effect can be used to investigate directly the natural shape of a $\gamma$ line and its superfine splitting, but this method is only applicable to a limited number of transitions. Doppler broadening of a line can be avoided by taking advantage of the modulation or periodic change in intensity that occurs with frequency, when two wave oscillations are imposed on each other with the transition of an excited state $E_0$ to two other levels $E_1'$ and $E_2'$. The spins and polarization of the radiation must be taken into account. Generally, modulation is observed only when the interfering components have the same polarization and phase relationship. In principle, because the modulation is related in phase, the purely quantum fluctuations can be separated from the classical statistical fluctuations. The angular correlation of $\gamma$ quanta in a magnetic field are examined in detail mathematically as a means of studying the hyperfine structure of nuclear spectra. Methods of measuring the interfering frequencies are discussed. (TTT)

**28610** DELAYED $\gamma$-TRANSITIONS IN $Na^{22}$. D. A. Varshalovich (Ioffe Inst. of Physics and Tech., Leningrad). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 287-8(Feb. 1964). (In Russian)

The $^{22}Na$ lifetime in the 593-kev ($I^\pi = 1^+$, T = 0) and the 666-kev ($I = 0^+$, T = 1) excited states were measured previously. It was found that the 593-kev $\gamma$ transition (E2) and the 73-kev $\gamma$ transition (M1) are delayed by a factor of 120 and 220, respectively, compared to estimates based on a single-particle model. It is pointed out that the decrease in probability of both these transitions can also be explained within the framework of a shell model with a spherical potential. According to the "spherical" model, the $^{22}Na$ ground state and the 593- and 666-kev excited states belong to a single multiplet $(d_{\frac{5}{2}})^6$, and the $d_{\frac{5}{2}}$ shell is just half-filled with $n = N/2$, where $N = 2(2j + 1)$. Balashov gave special selection rules for nuclei of this kind. It cannot be concluded from the delayed $\gamma$ transitions that the $^{22}Na$ nucleus is smoothly deformed. A definite conclusion can be reached only after measuring the quadrupole moment of $^{22}Na$. According to the model of a "deformed" nucleus, the quadrupole moment is mainly determined by deformation of the surface, and $Q(^{22}Na) = 25/14Q(^{23}Na) \simeq +0.18 \times 10^{-24}$ e · cm$^2$. According to the model of a "spherical" nucleus, the quadrupole moment of $^{22}Na$ should be equal to zero, since $n = N/2$. (TTT)

**28611** A NUMBER OF PROPERTIES OF "VIBRATION" LEVELS IN DEFORMED NUCLEI HAVING AN ODD MASS NUMBER A. L. K. Peker (Leningrad State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 289-94(Feb. 1964). (In Russian)

Gamma-vibration levels were found in the stable, odd nuclei $^{159}Tb$, $^{165}Ho$, $^{169}Tm$, $^{167}Er$, $^{185}Re$, and $^{187}Re$. These levels are analogous to the collective levels of even-even nuclei with $I^\pi = K^\pi = 2^+$. There are two levels with $K_1 = \Omega - \nu = \Omega - 2$ and with $K_2 = \Omega + \nu = \Omega + 2$ in an odd nucleus for a single level of an even-even nucleus with $K^\pi = \nu^\pi = 2^+$. Here $\Omega$ and $\nu$ are the projections of the angular moment of the nucleon and of the phonon on the symmetry axis of the nucleus. Levels of the $K_1$ and $K_2$ type were identified only in $^{159}Tb$ and $^{165}Ho$. Data on the energies and spins of $K_1$-type levels are compared with the energies of levels with $K^\pi = J^\pi = 2^+$ in neighboring even-even nuclei for the odd nuclei of $^{159}Tb$, $^{165}Ho$, $^{167}Er$, $^{169}Tm$, $^{185}Re$, and $^{187}Re$ and for the even-even nuclei of $^{158}Gd$, $^{164}Dy$, $^{166}Er$, $^{168}Er$, $^{184}W$, and $^{186}W$. Since the odd nuclei do not show $\beta$-variation or octopole vibration levels below the $\gamma$-vibration levels, it can be assumed that the order of collective levels is the same as in neighboring even-even nuclei. Hence, a study of the "vibration" levels in $^{153}Eu$ and $^{155}Gd$ would be of interest, since the neighboring even-even nuclei $^{152}Sm$ and $^{154}Gd$ have $\beta$-vibration levels (E = 685.6 kev) and $^{152}Sm$ has an octopole vibration level with E = 961 kev. The $K_1$ level lies below the $K_2$ level in all nuclei. The $K_1$ level always has less excitation energy than the level with $I = K = 2^+$ in the neighboring even-even nucleus. These criteria can be used as a guide in identifying "$\gamma$-vibration" levels for other odd deformed nuclei. With these guidelines, an analysis was made of levels of the $K_1$ type in $^{165}Er$, $^{171}Tm$, and $^{187}Os$. Octopole vibration levels were preliminarily identified in $^{223}Ac$, $^{225}Ac$, $^{227}Ac$, $^{225}Ra$, and $^{239}U$. $\beta$-vibration levels were found in $^{235}U$. (TTT)

**28612** ROTATIONAL BANDS ASSOCIATED WITH TWO-PARTICLE STATES OF DEFORMED EVEN-EVEN NUCLEI. L. K. Peker (Leningrad State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 295-7(Feb. 1964). (In Russian)

The bond between one pair of neutrons or protons is broken in a number of deformed, even-even nuclei. A method of estimating the "effective" moments of inertia of such nuclei is based on the formula that $J_0^A \simeq J_E^A + \delta J_1 + \delta J_2$. Here $J_E^A$ is the moment of inertia of an even-even nucleus with the same mass number A, in which all the nucleons are paired, and $\delta J_1$ and $\delta J_2$ are the contributions of the unpaired nucleons to the moment of inertia. On calculating the moment of inertia, the energies of members of a rotational band associated with a two-particle state can be determined from the formula $E = (\hbar^2/2J)[I(I + 1) - I_0(I_0 + 1)]$. The experimental data are compared with the theoretical value for the energies of rotational bands in $^{156}Gd$, $^{160}Dy$, $^{162}Dy$, $^{168}Er$, $^{230}Th$, $^{172}Yb$, $^{182}W$, and $^{232}U$. The good agreement between the experimental and calculated values of the rotational band energies shows that the contributions of both unpaired nucleons to the moment of inertia are independent of contributions from other levels. (TTT)

**28613** FEATURES EXPECTED OF THE DECAY OF 6-QUASIPARTICLE ISOMERIC STATES IN ODD-ODD NUCLEI HAVING A MASS NUMBER A ~ 240. L. K. Peker (Leningrad State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 298-301(Feb. 1964). (In Russian)

The isomeric state of the odd-odd nucleus $^{242}Am$ is the first example of a 6-quasiparticle state with a very large spin $K = I \geq 24$. Since $\Delta K > 4$ for any $\gamma$ transitions from a 6-particle state to lower 2-particle or 4-particle states, the $\gamma$ transitions are forbidden by the selection rules and the lifetime for the emission of $\gamma$ quanta should be long. This explains the existence of an excited, long-lived, isomeric state in $^{242}Am$. Analogous 6-quasiparticle states also occur in the neighboring odd-odd nuclei $^{240}Np$ and $^{244}Am$. The probability of spontaneous fission in these nuclei is very high compared to the probabilities of $\beta$ and $\alpha$ decay. It is believed that the decrease in the value of the potential barrier leads to much greater increase in the probability of spontaneous fission than in the probability of $\alpha$ decay. (TTT)

**28614** THREE-PARTICLE ISOMERIC STATES OF NUCLEI WITH AN ODD MASS NUMBER A. L. K. Peker (Leningrad State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 302-7(Feb. 1964). (In Russian)

The nuclei $^{93}$Mo ($T_{½}$ = 6.7 hrs), $^{135}$Cs ($T_{½}$ = 53 min), $^{177}$Lu ($T_{½}$ = 155 days), $^{207}$Po ($T_{½}$ = 2.8 sec), and $^{211}$Po ($T_{½}$ = 25 sec) have large spins and excitation energies. These states cannot be collective states because of the large half life. The large spins indicate that a number of unpaired nucleons are present in these nuclides. Since the excitation energy E < 2 Mev, only one pair of nucleons can be separated from each other, and hence these nuclides should all be three-quasiparticle nuclides. A relation exists between three-particle states and excited two-particle levels of neighboring even-even nuclei such that it is possible to establish definitely the configuration (the states of unpaired protons and neutrons) in a three-particle isomeric state. The above isotopes are compared with the known two-particle states in the neighboring even-even nuclei $^{92}$Mo, $^{136}$Ba, and $^{178}$Hf. The spins $I_{odd}$ and $I_{even}$ are related as follows: $I_{odd} = I_{even}$ (2p or 2n) + $j_0$(n,p), or $I_{odd} = I_{even}$ (2p or 2n) + $j_0$(n,p) − 1. Examples of isomeric states with high spin values are $^{138}$Ce, $^{140}$Nd, $^{135}$Cs, $^{131}$Sb, $^{133}$I, $^{137}$La, $^{139}$Pr, $^{141}$Pm, $^{176}$Yb, $^{178}$Hf, $^{180}$W, $^{179}$Ta, $^{181}$Re, $^{191}$Ir, and $^{91}$Zr. (TTT)

**28615** LEVEL ENERGIES AND TRANSITION PROBABILITIES AS A FUNCTION OF THE ROTATION FREQUENCY OF DEFORMED NUCLEI. V. M. Mikhailov. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 308-14(Feb. 1964). (In Russian)

The deviations from the simple rules of the rotational model of Bohr and Mottelson in the succession of levels and in the transition intensities indicate that the collective and internal motion of particles are not completely separated in real nuclei and that this coupling must be taken into account. In order to introduce corrections to the above simple model, it is assumed that the moment of inertia of the nucleus increases with the rotation frequency. This increase is connected with the nucleon reaction to the change in average field. The corrections are introduced by assuming that the hamiltonian of the system contains arbitrary exponents for the square of the rotational moment of the nucleus. The angular part of the corrections to the rotational energies and to the transition probabilities of multipolarity 1 and 2 at $\Delta K$ = 0, 1, 2 is given. Experimental parameters can be substituted in the formulas to show how large are the deviations in deformed nuclei from the simple rotational model. (TTT)

**28616** NEUTRON–PROTON INTERACTION AND THE LEVELS OF HEAVY, ODD-ODD NUCLEI. Yu. I. Kharitonov (Ioffe Inst. of Physics and Tech., Leningrad). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 315-24(Feb. 1964). (In Russian)

Nordheim (Rev. Mod. Phys., 23: 322(1951)) and Brennan and Bernstein (Phys. Rev., 120: 927(1960)) give rules for predicting the spin of the ground state of odd-odd nuclei. These rules are in good agreement with experiment whenever pair correlation and interaction of the outer nucleons with the core can be neglected. In a number of cases, a qualitative analysis of the nondiagonal matrix elements definitely indicates the spin of the ground state of an odd-odd nuclei and the position of a number of other levels including isomeric states. This approach is more fruitful than searching for selection rules in this case because of the existence of pair correlation and nucleon interaction with odd-odd nuclei. It is noted that the character of the splitting of the ground configuration as a function of the parity of the Nordheim number is different for light and heavy nuclei. (TTT)

**28617** THE SINGLE-POLE PORTION OF THE MAJORANA FORCES AND NUCLEON COUPLING IN LIGHT NUCLEI. V. G. Neudachin, V. N. Orlin, and Yu. F. Smirnov. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 326-36 (Feb. 1964). (In Russian)

It is known that $\alpha$-association effects in light nuclei are due to Majorana forces. Coupling of these forces may be analyzed within the frame work of the nuclear shell theory. Inasmuch as the radius of the forces is much smaller than the radius of the nucleus, the difference between the Wigner and Majorana forces disappears and therefore the coupling mechanism also becomes negligible. The symmetry effects of neutrons and protons act also for the forces involved in pair formation. In many cases the Majorana single-pole M(O) is probably primarily responsible for the coupling in light nuclei, confirming the fact that the more symmetrical the Young's scheme [f] of the orbital portion of the wave function, the larger the bond energy. The calculations have shown that there is a definite correlation between the bond energy of the nucleus and the sums of the $\alpha$ widths of their ground states, viewed as a function of the mass number A. At present it is not possible to establish this dependence with certainty in the range of light nuclei because there are only very few data available on the $\alpha$ width. The (d,$^6$Li) reaction is considered very suitable for obtaining such data. The correlation between bond energy and $\alpha$ width can be also examined by studying the $\alpha$-active isotopes of heavy elements, such as At, Po, or Rn. (TTT)

**28618** WAVE FUNCTIONS OF THE GROUND AND EXCITED STATES OF THE 1p-SHELL NUCLEI IN THE INTERMEDIATE-BOND MODEL. A. N. Boyarkina (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 337-58(Feb. 1964). (In Russian)

The wave functions derived by D. Kurath (Phys. Rev., 101: 216(1956)), calculating the probability of electromagnetic transitions of the 1p shell, are also needed for determining other characteristics of the nucleus, such as nucleon and multiparticle width, the probability of partial transitions in the case of absorption of $\gamma$ quanta, or inelastic scattering of the particles; these much needed data are not available in the literature. Therefore, while developing the theory of the quasielastic scattering of fast protons on light nuclei, the wave functions of the ground and excited states of all the 1p nuclei were also calculated within the framework of the intermediate bond model. These calculations are published as an appendix in order to provide the experimentalists working with light nuclei with an independent interpretation of the data, obtained by a more detailed method than the jj or LS bond approach. The optimum values of the other parameters of the method, the amplitude of the spin-orbit coupling and the radial integrals of the L and K pair interactions, were determined individually for each nucleus on the basis of the best agreement with the experimental value for the lowest energy level of normal parity, assuming that the most strongly excited states ($E_{exc}$ = 20 to 40 Mev) are the least stable. The tables presented include wave functions of nuclei from A = 6 to A = 16. (20 pages of graphs and tables). (TTT)

**28619** QUASI-ELASTIC SCATTERING OF FAST PROTONS ON LIGHT NUCLEI WITH EMISSION OF DEUTERONS. V. V. Balashov and A. N. Boyarkina. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 359-70(Feb. 1964). (In Russian)

A spectroscopic method based on the analysis of partial

transitions was used to describe reactions involving the emission of complex nucleon clusters. In view of the scarcity of data on the escape of deuterons by fast quasi-elastic processes, experiments were carried out on the yields, limiting the study to 1p-shell nuclei; only states with undisturbed 1s shells were considered. The calculations were carried out within the framework of the shell model, taking nucleon correlations and symmetry rearrangements according to Pauli's principle into account. Thus, the light atoms from A = 5 to A = 7 were treated by the supermultiplet theory and the heavier ones by the intermediate bond theory. It was assumed that the radial single-particle wave functions were of the oscillator type. It was found that even in the simplest reaction, $^{6}$Li(p,pd)$^{4}$He, the pulse distribution of deuterons differs markedly from the results yielded by the cluster model. The calculations indicate that the product of a nuclear reaction stays in the excited, rather than in the ground state. The concept of partial pulse distribution was applied to the quasi-scattering reactions involving emission of $\alpha$ particles. Specific examples of excitation spectra in the (x,xa) reaction were reported previously. (TTT)

**28620** SUPERFLUIDITY OF NUCLEAR MATTER. S. G. Kadmenskii (State Univ., Voronezh, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 371-6(Feb. 1964). (In Russian)

The problem of the superfluidity of nuclear matter was examined by considering the equation of the energy gap from the viewpoint of perturbation theory, under the conditions of the two-parameter model developed by M. Ya Amus'ya. The study was based on the energy-gap equation of A. B. Migdal for a spatially homogeneous system. The chief difficulty arises from the consideration of the repulsive core; this calculation was based on the studies of L. D. Landau. It was found that the core matrix element may be replaced by the amplitude of the two-particle scattering in vacuum only if the energy-gap equation is recalculated at the same time. Scattering experiments indicated that the interaction of similar nucleons in the singlet state possess an attractive character and therefore the energy-gap equation may be solved if the nuclear matter is within the boundaries of the gas approximation. This conclusion is valid even if the spin and isotopic dependence of the nuclear forces is taken into account. It was concluded that the criterion of superfluidity cannot be fulfilled and therefore the nuclear matter cannot possess superfluidity within the limitations of the two-parameter model with Wigner forces. The conclusion is not absolutely valid if exchange forces are acting in the system. (TTT)

**28621** THE FRAGMENTATION MECHANISM TAKING PLACE DURING THE INTERACTION OF HIGH-ENERGY PARTICLES WITH NUCLEI. L. P. Rapoport and A. G. Krylovetskiĭ (State Univ., Voronezh, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 388-93(Feb. 1964). (In Russian)

It was observed repeatedly that when nuclei are irradiated by high-energy particles, lighter nuclei, with Z > 3, are knocked from the nucleus as the result of the fragmentation reaction. Direct tests on the scattering of fast nucleons on the nuclei indicated a small cross section for a large pulse transfer. A different fragmentation mechanism, based on the concept of the collective motion in the nuclei, is proposed. This theory was found useful to explain quantitatively several phenomena that could not be clarified by the cascade–evaporation theory. It is assumed that the heavy fragments are knocked out by a Mach shock wave, formed by the passage of particles possessing relativistic velocities through the nuclear matter. By treating the nucleons in the nucleus according to the nonstatic fermion-gas theory, a hydrodynamic equation is obtained. The probability of the emission of a fragment is determined fundamentally by the probability of the formation of a cluster on the surface of the nucleus. The total amount of the fragments emitted by the shock wave is dependent on the dissipation of the wave as a result of the pressure and velocity changes caused by its motion to the surface. If it is assumed that a large part of the particles with $Z \leq 2$ is emitted from the nucleus by the cascade–evaporation method and those with $Z \geq 3$ by the above mechanism, then almost all of the high-energy phenomena can be explained, at least qualitatively. (TTT)

**28622** THE $\gamma$-RADIATION OF PROTACTINIUM-233. V. V. Berdikov and A. N. Silant'ev. Izv. Akad. Nauk SSSR, Ser. Fiz., 28: 394-5(Feb. 1964). (In Russian)

The spectra of the internal conversion electrons and of photoelectrons knocked from Au and Ag converters by the $\gamma$ rays of $^{233}$Pa were studied previously by several authors. This problem was further investigated, using an earlier $4\pi\ \beta\gamma$ coincidence method of the authors. The total absolute intensity of the 301-, 312-, and 314-kev $\gamma$ rays was found to be (49 ± 5)%, while the absolute intensity of the K-radiation, together with 74-, 86-, and 104-kev $\gamma$ rays, was 33 ± 4%; the total intensity of the 370-, 400-, and 417-kev $\gamma$ rays was estimated at 5%. The absolute intensity of the 301-, 312-, and 340-kev $\gamma$ lines was calculated at 2, 42, and 5%, respectively. The data of P. Ong and P. Kramer on the number of conversion electrons in the K shell were used to calculate the decay scheme for the 312-kev transition. These data agreed well with the results of the present work on the intensity of the K radiation and with the assumed decay scheme. The conversion coefficients of the 312-kev $\gamma$ rays were 0.6, 0.1, and 0.2; Ong, et al., reported the relative intensities of the K, L, and M shell conversion electrons as 100, 20, and 4.5. The 312-kev transition intensity was found to be 71%, agreeing well with earlier direct measurements; the total number of transitions to the ground state amounted to 97%. (TTT)

**28623** EXCITATION FUNCTIONS FOR THE $^{184}$W(d,p)$^{185}$W, $^{186}$W(d,p)$^{187}$W AND $^{184}$W(d,2n)$^{184}$Re REACTIONS; AND HALF-LIVES OF $^{185}$W AND $^{187}$W. R. L. Andelin (Los Alamos Scientific Lab., N. Mex.). J. Inorg. Nucl. Chem., 26: 1117-20(June 1964). (LADC-6159)

Excitation functions were determined for the reactions $^{184}$W(d,p)$^{185}$W, $^{186}$W(d,p)$^{187}$W, and $^{184}$W(d,2n)$^{184}$Re, and half life determinations of $^{185}$W and $^{187}$W were made. Cross section data are tabulated. (P.C.H.)

**28624** THE USE OF IRIDIUM FOILS FOR THE MEASUREMENT OF THE $^{240}$Pu RESONANCE ESCAPE PROBABILITY IN PLUTONIUM-FUELLED REACTOR ASSEMBLIES. D. Jakeman and E. J. Maunders (Atomic Energy Establishment, Winfrith, Dorchester, Eng.). J. Nucl. Energy, Pt. A & B, 18: 173-90(Apr. 1964).

Details are given of a method of analysis used to derive a value of the $^{240}$Pu resonance escape probability, $p_{240}$, in plutonium-fueled reactor systems from observations of the relative reaction rates of $^{192}$Ir and $^{194}$Ir. Preliminary normalization experiments in systems without $^{240}$Pu have provided a useful check on the nuclear data, and a consistent set of data was obtained. Measurements in a plutonium–graphite heterogeneous intermediate assembly in which the ratio of carbon atoms to $^{240}$Pu atoms was 36,900 gave a value of $p_{240}$ equal to 0.835 ± 0.020, which is in good agreement with theoretical predictions. (auth)

**28625** THE 2′ → 2 ELECTRIC MONOPOLE TRANSITION IN $Hg^{198}$. Mitsuo Sakai, Masao Nozawa, Hidetsugu Ikegami, and Toshimitsu Yamazaki (Tokyo Univ.). Nucl. Phys., 53: 529-39(May 1964).

An electric monopole transition in the 676-kev 2′ → 2 transition in $^{198}Hg$ was investigated by means of an electron-gamma angular correlation experiment on the $2^+$(676 kev)$2^+$ (412 kev)$0^+$ gamma-ray cascade following the decay of 5.3-h $^{198}Tl$. The electron analyzer was a beta spectrometer especially designed for this type of experiment. The data were analyzed by taking into account nuclear structure effects on the M1 internal conversion process. Two values of the strength parameters $\rho$ were found to be consistent with the experimental results. They are $0.21 \leqq \rho \leqq 0.42$ and $-0.42 \leqq \rho \leqq -0.29$ with corresponding $\lambda$ value of $5 \leqq \lambda \leqq 26$ and $31 \leqq \lambda \leqq 52$, respectively, where $\lambda$ is defined as the ratio of the penetration matrix element to the normal gamma-ray matrix element. The $\rho$ values were calculated with the assumption $B(E2; 2' \rightarrow 2)/B(E2; 2 \rightarrow 0) = 2$. The large $\rho$ value may imply a large admixture of particle states in the $2^+$ levels concerned. (auth)

**28626** THE REACTION $^{33}S(p,p'\gamma)^{33}S$. C. Van der Leun and P. M. Endt (Rijksuniversiteit, Utrecht). Nucl. Phys., 53: 540-4(May 1964).

In the energy range $E_p = 1.2$ to 3.2 Mev, forty-four resonances were found in inelastic proton scattering from $^{33}S$. The energies, widths, and relative strengths are reported. No indication was found at these resonances for the existence of a 1.4-Mev level of $^{33}S$, suggested by shell-model calculations. The 1.96-Mev level of $^{33}S$ predominantly (>97%) decays to the ground state; its spin is $\geqq \frac{3}{2}$. (auth)

**28627** THE ANALYSIS OF NUCLEAR EVAPORATION SPECTRA. T. Darrah Thomas (Princeton Univ., N. J. and Brookhaven National Lab., Upton, N. Y.). Nucl. Phys., 53: 558-76(May 1964). (PPAD-491E)

The angular momentum dependence of the level density has not been properly taken into account in the analysis of nuclear evaporation spectra. The question of whether or not this neglect is responsible for the reported variation of level density parameters with changes in the energy of the bombarding particle is investigated. It apparently is not. However, it is shown that the improper treatment of the angular momentum dependence of the level density and the use of high-energy approximations to the level density in the analysis of evaporation spectra give erroneous values of the level density parameter a. An analysis taking these factors into account gives a value of $a \approx \frac{1}{12}$ A for the case considered, in agreement with the value predicted from the Fermi gas model of the nucleus. Several approximate formulas are discussed to indicate the nature of evaporation spectra when certain assumptions are valid. (auth)

**28628** ANGULAR MOMENTUM EFFECTS IN NEUTRON EVAPORATION. T. Darrah Thomas (Princeton Univ., N. J. and Brookhaven National Lab., Upton, N. Y.). Nucl. Phys., 53: 577-92(May 1964). (PPAD-494E)

The statistical model of nuclear reactions was used to calculate the effects of angular momentum on the evaporation of neutrons. The systems considered are $^{210}Po$ with excitation energy of 24 Mev and angular momenta up to 26 ħ; $^{209}At$ with excitation energy of 95 Mev and angular momenta up to 68.5 ħ; $^{55}Mn$ with excitation energy of 26 Mev and angular momenta up to 24.5 ħ; and $^{79}Rb$ with excitation energy of 128 Mev and angular momenta up to 73.5 ħ. Quantities calculated are the average angular momentum change on evaporation of one neutron, the width for neutron emission and the average kinetic energy of the first evaporated neutron, all as a function of the angular momentum of the compound nucleus. Some approximate formulas that aid in understanding the behavior of these quantities are discussed. A comparison is made with other similar calculations and with the existing experimental data. (auth)

**28629** ANGULAR DISTRIBUTIONS OF FAST PHOTONEUTRONS. F. R. Allum, T. W. Quirk, and B. M. Spicer (Univ. of Melbourne, Victoria). Nucl. Phys., 53: 545-57 (May 1964).

Using an $^{27}Al(n,\alpha)^{24}Na$ threshold detector, the angular distributions of fast photoneutrons from eleven elements were measured. For 34-Mev incident bremsstrahlung the angular distributions were found to be asymmetric about a position 90 degrees relative to the direction of the incident bremsstrahlung and were peaked in a forward direction. The present experiment indicates that the amount of forward peaking is an increasing function of atomic number. This general trend is in agreement with the predictions of a recently proposed model in which the forward peaked photoneutron angular distributions are explained in terms of the observed forward asymmetry in the corresponding photoproton angular distributions. Results are given for Be, C, Al, Ti, Cr, Cu, Sn, Ba, Ta, Pb, Bi. (auth)

**28630** THE 3.06 AND 3.85 Mev STATES IN $O^{17}$. T. K. Alexander, C. Broude, and A. E. Litherland (Chalk River Nuclear Labs., Chalk River, Ont.). Nucl. Phys., 53: 593-604(May 1964).

The 3.06- and 3.85-Mev states in $^{17}O$ were excited by the reaction $^{14}C(\alpha,n)^{17}O$ and the gamma de-excitation of these states was observed in coincidence with neutrons. The attenuated Doppler shifts of the gamma rays were measured and lead to lifetime estimates of 1.2 and $\leqq 0.25 \times 10^{-13}$ sec, respectively. The n-$\gamma$ angular correlations from the two states were also measured. These correlations alone do not lead to unique spin assignments but in conjunction with the lifetime measurements, they confirm the $\frac{1}{2}^-$ assignment to the 3.06-Mev state but favor $\frac{5}{2}^-$ over $\frac{7}{2}^-$ for the 3.85-Mev state. Upper limits were put on two unobserved decay modes of these levels. They are 2% for the decay of the 3.06-Mev state directly to the ground state, and 5% for the cascade of the 3.85-Mev state through the first excited state. (auth)

**28631** MEASUREMENT OF POLARIZATION IN p–$\alpha$ ELASTIC SCATTERING. C. Manduchi, G. C. Nardelli, M. T. Russo-Manduchi, and G. Zannoni (Università, Padua and Istituto Nazionale di Fisica Nucleare, Padua). Nucl. Phys., 53: 605-12(May 1964).

The angular dependence of polarization of protons elastically scattered from alpha particles was observed by measuring the asymmetry obtained by scattering highly polarized 4.5-Mev protons in helium. (auth)

**28632** LONGITUDINAL POLARIZATION OF BETA RAYS FROM $^{198}Au$. J. Van Klinken (Rijksuniversiteit, Groningen, Netherlands). Nucl. Phys., 53: 613-17(May 1964).

The longitudinal polarization of beta rays from neutron-irradiated gold sources was determined with an improved method of Mott scattering, using double scattering of unpolarized electrons for calibration. At 625 and 236 kev the measured degree of polarization is compatible with $-v/c$. A deviation from $-v/c$ of $(6 \pm 2)\%$ is found at 172 kev and of $(29 \pm 7)\%$ at 92 kev. These deviations cannot be interpreted unambiguously because of a large contribution of $^{199}Au$ at these energies. If only the 965-kev decay branch of $^{198}Au$ is responsible for the smaller polarization at low

energies this energy dependence cannot be explained by the theory of first-forbidden beta decay. (auth)

**28633** THREE ABSOLUTE ENERGY CALIBRATION POINTS FOR PROTONS BELOW 3 Mev. R. O. Bondelid and J. W. Butler (Naval Research Lab., Washington, D. C.). Nucl. Phys., 53: 618-24(May 1964).

An electrostatic beam-energy analyzer was used to make absolute energy measurements of the following resonances and threshold: $^{9}Be(p,\gamma)^{10}B$, 1083.2 ± 0.4 kev; $^{15}N(p,\alpha\gamma)^{12}C$, 897.37 ± 0.29 kev; and $^{18}O(p,n)^{18}F$, 2573.72 ± 0.77 kev. The widths of the two resonances were measured to be 3.25 ± 0.33 and 1.5 ± 0.3 kev, respectively. For calibration purposes, the peak of a thin-target resonance yield curve, the midpoint of the rise of a thick-target resonance yield curve, and the intercept of the extrapolated threshold yield curve do not correspond precisely to the above values, but corrections are given to enable such yield curves to be used directly for energy calibration of proton beam-energy analyzers. (auth)

**28634** ELASTIC SCATTERING OF 26 Mev DEUTERONS. H. R. E. Tjin A Djie, F. Udo, and L. A. Ch. Koerts (Instituut voor Kernphysisch Onderzoek, Amsterdam). Nucl. Phys., 53: 625-42(May 1964).

Angular distributions from 5 to 160° were measured for elastic scattering of 26.0-Mev deuterons by Mg, Fe, Ni, Zn, Zr, Ce, and Ta, and for scattering of 25.3-Mev deuterons by Ag and Au. The results are similar to those observed at lower energies, i.e., the oscillatory pattern that characterizes the distributions for the lighter elements Mg, Fe, Ni, Zn, and Zr reduces with increasing atomic number to a modulation on the exponential drop-off of the differential cross section, which is characteristic for the heavy elements such as Ta and Au. This gradual change in character is interrupted by the behavior of the angular distributions of Ag and Ce in which the order of the change is reversed, the oscillations in the case of Ce being more pronounced than those for Ag. The regularity in the diffraction patterns is disturbed for Zr, in which case the third and fourth maximum are merging. The data are presented in graphical and in numerical forms. (auth)

**28635** ISOBARIC ANALOGUE STATES AND THE SHELL MODEL. W. T. Pinkston (Franklin Inst., Swarthmore, Penna.). Nucl. Phys., 53: 643-9(May 1964).

It is pointed out that the calculation of the energy of the isobaric analog state using the nuclear shell model provides a test of the consistency of the two-body interaction used and the empirical single-body energies. It is suggested that such calculations would provide information on the effective two-body interaction in nuclear matter. The model of Ikeda, Fujii, and Fujita is used to illustrate these ideas and is generalized to include neutron pairing correlations. (auth)

**28636** COMPARISON OF STRONG COUPLING AND DISTORTED WAVE BORN APPROXIMATION CALCULATIONS. A. P. Stamp and J. R. Rook (Oxford Univ.). Nucl. Phys., 53: 657-66(May 1964).

The inelastic differential cross sections calculated by the distorted-wave Born approximation and the strong-coupling approximation are compared when the parameters of the distorting potentials are restricted by the requirement that the elastic scattering cross sections are equivalent. For the reaction $^{20}Ne(p,p')^{20}Ne$ it is found, contrary to the usual belief, that the DWBA underestimates the cross section. It is also shown analytically that the DWBA and SCA are not necessarily equivalent. (auth)

**28637** TOTAL NEUTRON CROSS SECTIONS OF Zr ISOTOPES IN THE ENERGY RANGE UP TO 20 kev. S. S. Moskalev, H. V. Muradian, and Yu. V. Adamchuk (Kurchatov Atomic Energy Inst., Moscow). Nucl. Phys., 53: 667-72 (May 1964).

The total neutron cross sections for separated Zr isotopes are measured by a time-of-flight technique at the linear electron accelerator of the Kurchatov Atomic Energy Institute. The best resolution in these measurements was 0.006 μsec/m. The parameters of the discovered levels are determined and isotopic identification is made. The values of the strength functions for Zr isotopes are in agreement with the predictions of the optical model. (auth)

**28638** THE RADIATIVE DECAY OF THE 7.66 Mev LEVEL OF $C^{12}$. I. Hall and N. W. Tanner (Oxford Univ.). Nucl. Phys., 53: 673-84(May 1964).

The 7.66-Mev excited state of $^{12}C$ was studied using the reaction $^{10}B(^{3}He,p)^{12}C$. Coincidences were recorded between protons detected by a scintillation counter and the corresponding recoil carbon ions detected by a semiconductor counter after magnetic analysis. The branching ratio of the decay of the 7.66-Mev state to the ground state, $\Gamma_g = \Gamma_{e^\pm} + \Gamma_\gamma$ to the decay to $^{8}Be + \alpha$ was deduced as $\Gamma_g/\Gamma = (3.5 \pm 1.2) \times 10^{-4}$. This result is in agreement with other recent measurements. (auth)

**28639** THE DECAY OF 33 sec $Kr^{90}$. R. H. Goodman, J. E. Kitching, and M. W. Johns (McMaster Univ., Hamilton, Can.). Nucl. Phys., 54: 1-16(May 1964).

The separation of 33 sec $^{90}Kr$ from the other fission products was achieved by gas chromatography and the resulting activity studied by the techniques of scintillation spectroscopy. The energies and intensities of 36 transitions in $^{90}Rb$ were measured. Beta-gamma and gamma-gamma coincidence experiments have led to the formulation of a decay scheme which involves 27 of these transitions and establishes levels in $^{90}Rb$ at 0.0, 0.12, 0.23, 0.656, 1.63, 1.78, 1.80, 2.02, 2.28, 2.41, 2.48, 2.70, 3.19, and 3.60 Mev. The decay energy of $^{90}Kr$ is 4.56 ± 0.02 Mev. (auth)

**28640** A STUDY OF THE REACTIONS $Nb^{93}(n,\alpha)Y^{90}$ AND $Pr^{141}(n,\alpha)La^{138}$ AT 14 Mev. P. Kulisić (Institut "Rudjer Boskovic," Zagreb), V. Ajdacić, N. Cindro, B. Lalović, and P. Strohal. Nucl. Phys., 54: 17-27(May 1964).

The energy and angular distribution of alpha particles from $(n,\alpha)$ reactions on $^{93}Nb$ and $^{141}Pr$ was measured using a semiconductor telescopic detector. In the case of $^{93}Nb$ the values of the total cross section and angular distribution show a predominantly evaporative process. Energy spectra can also be fitted with Fermi gas level densities (a = 6.7 Mev) but the agreement is not quite satisfactory. In the case of $^{141}Pr$ the process is predominantly direct, presumably a knock-out mechanism. An evaporation component, if present, is less than 0.05 mb/sr. The comparison of the cross section for the (n,p) ($\sigma$ = 4 mb) and $(n,\alpha)$ ($\sigma$ = 3 mb) reactions on $^{141}Pr$ suggests the presence of strong correlations between nucleons in the nuclear surface. (auth)

**28641** CONVERGENCE OF BORN SERIES AND THE EXISTENCE OF BOUND STATES. [PART] II. R. Huby and J. R. Mines (Univ. of Liverpool). Nucl. Phys., 54: 28-32(May 1964).

An extension of previous results which showed how the non-existence of bound states in central potentials ±W and $-|W|$ provided respectively necessary and sufficient conditions for the convergence of Born series in the potential

W at all energies is presented. The question has arisen whether this necessary condition may also be sufficient, but it is proved that this is not the case. The discussion embraces a new Born series, that for the Green function of the Schrödinger equation, and also a wider class of potential than before. (auth)

**28642** ANGULAR DISTRIBUTIONS OF NEUTRONS ELASTICALLY SCATTERED FROM $O^{18}$. T. R. Donoghue, A. F. Behof, and S. E. Darden (Univ. of Notre Dame, Ind.). Nucl. Phys., 54: 33-48(May 1964).

The angular distributions of neutrons elastically scattered from $^{18}O$ were measured for neutron energies between 405 and 2702 kev by the recoil-particle method. For these measurements, a proportional counter filled with carbon dioxide enriched to 97.2% in $^{18}O$ was irradiated with neutrons, and the recoil spectra were recorded by a 256-channel pulse-height analyzer. Subtraction of the carbon recoil spectra yielded the $^{18}O$ spectra. The results were analyzed in conjunction with the total neutron cross section measurements of Vaughn et al., using one- and two-level nuclear dispersion theory. New states in $^{19}O$ were located at excitation energies of 5.097, 6.13, and 6.20 Mev. Definite spin and parity assignments of $\frac{3}{2}^-$, $\frac{1}{2}^-$, and $\frac{5}{2}^+$, were made to the states at excitation energies of 4.587, 5.097, and 5.43 Mev, respectively. In addition, probable spin and parity assignments of $\frac{3}{2}^+$, $\frac{1}{2}^-$, and $\frac{1}{2}^-$, have been made to the states at excitation energies of 6.13, 6.20, and 6.271 Mev, respectively. In the excitation energy region near 5.5 Mev, there is definite evidence for an additional level, for which a probable assignment of $\frac{1}{2}^-$ was made. (auth)

**28643** ELASTIC SCATTERING OF NEUTRONS FROM $N^{15}$. T. R. Donoghue, A. F. Behof, and S. E. Darden (Univ. of Notre Dame, Ind.). Nucl. Phys., 54: 49-55(May 1964).

Angular distributions for the elastic scattering of neutrons from $^{15}N$ were measured in the neutron energy interval between 440 and 1960 kev, corresponding to the excitation energy region from 2.71 to 4.33 Mev in $^{16}N$. The distributions were measured by observing the recoil spectra from a $^{15}N$-filled proportional counter irradiated by neutrons. Total cross sections were determined by normalizing relative cross sections obtained from the integrated angular distributions to published total cross-section data. In addition to a previously observed resonance at 1960 kev, a resonance formed by $l = 1$ neutrons was found at a neutron bombarding energy of 940 kev, corresponding to an excitation energy of 3.37 Mev in $^{16}N$. For neutron energies below 900 kev, the angular distributions are isotropic, while in the energy region 1000-1900 kev the shapes of the distributions change little with energy. (auth)

**28644** THE d(p,2p)n REACTION AT 50 Mev. R. J. Griffiths and K. M. Knight (N.I.R.N.S., Chilton, Berks, Eng.). Nucl. Phys., 54: 56-64(May 1964).

Proton pairs from a liquid deuterium target, bombarded with 50-Mev protons, were detected by scintillation counter telescopes and the correlated energy spectra recorded on magnetic tape. Deviations from a simple theory were observed which may be interpreted as due to the breakdown of the impulse approximation in this energy region. (auth)

**28645** ANGULAR MOMENTUM EFFECTS ON THE DECAY OF COMPOUND NUCLEI. Camilla Hurwitz, Sylvia J. Spencer, R. A. Esterlund, B. D. Pate, and J. B Reynolds (Washington Univ., St. Louis). Nucl. Phys., 54: 65-85 (May 1964).

Data are presented on the energy distribution of emitted particles from the $^{103}Ih(\alpha,\alpha')$, $^{103}Rh(\alpha,p)$, and $^{92}Mo(\alpha,p)$ reactions. Data from these and other experiments for particles expected to arise from compound nucleus formation and decay were subjected to analysis via the compound-statistical model for nuclear reactions. The calculations take into account the angular momentum distribution of the compound and residual nuclei. The apparent variation of level density parameter with changing bombarding energy observed in the results of previous analyses of similar data continue to be observed in the results. (auth)

**28646** GAMMA-GAMMA DIRECTIONAL CORRELATION MEASUREMENTS IN THE DECAY OF $Ba^{133}$. L. I. Yin and M. L. Wiedenbeck (Univ. of Michigan, Ann Arbor). Nucl. Phys., 54: 86-96(May 1964).

The gamma rays following the electron capture decay of $^{133}Ba$ were studied using coincidence and directional correlation techniques. The existence of gamma rays with energies of 162 and 222 kev was ascertained. The correlation functions for the 356-82 kev, 302-82 kev, 80-82 kev and 276-162 kev cascades were found. The results support the spin sequence of $\frac{7}{2}^+$, $\frac{5}{2}^+$, $\frac{5}{2}^+$, $\frac{3}{2}^+$, and $\frac{1}{2}^+$, for the ground state, 82, 162, 384, and 438-kev levels of $^{133}Cs$. The measured mixing ratios of the following gamma rays are: 80 kev: (63 ± 9)% E2 + (37 ± 9)% M1; 82 kev: (97.6 ± 0.1)% M1 + (2.4 ± 0.1)% E2; 162 kev: (95.1 ± 0.6)% E2 + (4.9 ± 0.6)% M1; 276 kev: pure E2; 302 kev: (99.7 ± 0.1)% M1 + (0.3 ± 0.1)% E2; 356 kev: pure E2. (auth)

**28647** SUM RULES FOR THE SCATTERING OF HIGH-ENERGY ELECTRONS BY $O^{16}$. G. R. Bishop, D. B. Isabelle, and C. Betourne (Ecole Normale Supérieure, Orsay, France). Nucl. Phys., 54: 97-113(May 1964).

Measurements were made on the cross section for scattering of electrons by $^{16}O$ as a function of excitation energy for various experimental conditions. From the data, experimental values are computed for different sum rules which are compared with theoretical predictions. The sum rules evaluated are the integrated cross section at fixed incident energy and scattering angle, the integrated cross section and the energy weighted sum rule at fixed momentum transfer, and the integrated inelastic cross section at fixed momentum transfer and fixed scattering angle. The results demonstrate the effects of the Pauli exclusion principle and of charge exchange forces on the sum rules. (auth)

**28648** STUDY OF THE GIANT RESONANCE OF HEAVY NUCLEI BY SCATTERING OF BREMSSTRAHLUNG RADIATION. M. Langevin, J. M. Loiseaux, and J. M. Maison (Faculte des Sciences, Orsay, France). Nucl. Phys., 54: 114-24(May 1964). (In French)

Differential cross sections and angular distributions of scattered bremsstrahlung photons in the giant resonance region were studied for Ta, Ho, Er, Tb, Th, and Au nuclei. For the deformed nuclei, the obtained results show that there exists a tensor contribution to the scattering cross sections. The cross sections and the angular distributions can be explained in the neighborhood of the giant resonance with a Danos-Okamoto collective model using an ellipsoidal deformation for Ta and Er had a triaxial deformation for Ho and Tb. Beyond the giant resonance maximum, the angular distribution results can be explained by a small quadrupole contribution to the predominantly dipole interaction. (auth)

**28649** THE THEORY OF PHOTONUCLEAR REACTIONS ON LIGHT NUCLEI WITH THE EMISSION OF HIGH-ENERGY DEUTERONS. G. M. Shklyarevskii (Inst. of Physics and Tech., Leningrad). Nucl. Phys., 54: 125-8 (May 1964).

The anomalous threshold in photonuclear reactions on light nuclei for the emission of high-energy deuterons is considered. It is also shown that the angular correlation of a deuteron and a nucleon emitted by an excited nucleus must have a certain dependence on the nucleon energy. (auth)

**28650** LEVELS IN $Ru^{100}$ EXCITED IN THE DECAY OF $Rh^{100}$. Masahiro Koike, Kazuo Hisatake, Naoki Ono, and Kaoru Takahashi (Tokyo Inst. of Tech.). Nucl. Phys., 54: 129-47(May 1964).

The nuclear structure of $^{100}Ru$ was studied by the spectra of gamma rays and internal conversion electrons following the decays of $^{100}Rh$ and $^{100}Pd$ using coincidence scintillation spectrometers and a beta spectrometer. The radioactive sources were produced by nuclear reactions of $^{100}Ru(p,n)^{100}Rh$ and $^{103}Rh(p,4n)^{100}Pd$. The energies (in Mev) of the observed gamma rays are: 0.362 (weak), 0.444(9), 0.538 (100), 0.744 (weak), 0.820 (29), 1.036 (3), 1.109 (1.5), 1.34 (10), 1.36 (13), 1.55 (26), 1.92 (11), 2.37 (44), and 0.51 (15) (annihilation radiation), where the relative intensities are written in parentheses. All internal conversion lines observed previously were confirmed except for the 0.27-Mev line, and in addition some new internal conversion lines associated with transitions of 0.585, 0.654, 0.685, 1.036, and 1.344 Mev were found. The new level of 1.88 Mev of $^{100}Ru$ is proposed from gamma-gamma coincidence and internal conversion experiments, and the level of 3.21 Mev reported previously was removed in consequence of the absence of the 0.301-Mev transition. The K-internal conversion coefficients of transitions in $^{100}Ru$ were determined. The gamma-gamma directional angular correlations for the 0.538-0.820, 0.538-1.34, 0.538-2.37 1.36-1.11, 1.36-1.55, and 0.538-1.92 Mev cascades were studied. The E2-M1 mixing ratio $\delta$ of the transition between the second and the first $2^+$ state of $^{100}Ru(2' \rightarrow 2$ transition) was determined to be $-3.1$. The log ft values of the beta decay from the ground state of $^{100}Rh$ to levels of $^{100}Ru$ were obtained. From these results, the spins and parities of the excited states of $^{100}Ru$ were assigned. The excited states and their spins and parities in $^{100}Ru$ are as follows: 0.538 ($2^+$), 1.36 ($2^+$), 1.88 ($3^+$), 2.11 (?), 2.47 ($2^-$ or $3^-$) and 2.91 ($2^-$), where the numbers are energies in Mev and those in parentheses are spins and parities. (auth)

**28651** THE POSSIBLE EXISTENCE OF FOUR NEW STATES IN $Be^8$. F. W. Prosser, Jr. and F. L. Wilson (Univ. of Kansas, Lawrence). Nucl. Phys., 54: 148-54(May 1964).

The existence of four, previously unknown, excited states of $^8Be$ was recently proposed by Cavallaro et al. from their study of the $^7Li(p,\gamma)^8Be$ and $^7Li(p,\gamma\alpha)^4He$ reactions. A systematic search was made of the $\alpha$ and $\gamma$ spectra produced by proton bombardment of Li and of the $^7Li(p,\gamma)^8Be$ differential cross section for evidence to support this proposal and none was found. An attempt to find $\alpha$-$\gamma$ coincidences for states in $^8Be$ above the broad, 2.9-Mev state was also unsuccessful. Alternate interpretations of their results, primarily in terms of target contamination, are given. (auth)

**28652** ANALYSIS OF $\Lambda$ HYPERFRAGMENTS ON THE SEPARABLE POTENTIAL MODEL. [PART] I. G. Bhamathi and S. Indumathi (Univ. of Madras). Nucl. Phys., 54: 161-70(May 1964).

The hyperfragments $_\Lambda H^3$, $_\Lambda He^5$ and $_\Lambda Be^9$ are analysed on the separable potential model. The interaction-strength parameters $\lambda_{\Lambda\alpha}$ and $\lambda_{\Lambda N}$ are obtained. The value of $\lambda_{\Lambda N}$ obtained by solving the three-body problem for $_\Lambda H^3$ leads to an unbound $\Lambda$-nucleon system in agreement with the experimental results. (auth)

**28653** ELECTRON CAPTURE AFTER-EFFECTS IN $Cd^{111}$. Martin Salomon (Uppsala Univ.). Nucl. Phys., 54: 171-6(May 1964).

The integral and differential angular correlation of the 173-247 kev gamma cascade in $^{111}Cd$ was investigated at different temperatures in $In_2O_3$ polycrystalline sources. At 280°C a static electric quadrupole interaction is present with an interaction frequency $\omega_0 = 180$ MHz. At room temperature the static perturbation is mixed with a time dependent perturbation probably due to the ionized states in which Cd atoms are left after electron capture in $^{111}In$. (auth)

**28654** SCATTERING OF COSMIC RAY MUONS BY LEAD AT A MOMENTUM BETWEEN 200 AND 1500 Mev/c. G. Bizard, J. Duchon, J. Milliard, J. P. Patry, M. Scherer, and J. Sequinot (Faculte des Sciences, Caen, France). Nucl. Phys., 56: 385-93(Aug. 1964). (In French)

Results on muon scattering in lead are given for cosmic rays in the momentum interval 200 to 1500 Mev/c. Two Wilson chambers were used, one with magnetic field, the other with lead screens. Results are in better accord with Olbert's theory than with Molière's. (auth)

**28655** ANGULAR DISTRIBUTION FOR THE $T(d,n)He^4$ REACTION AT 1 AND 3 Mev DEUTERON ENERGY. A. Paulsen and H. Liskien (EURATOM. Geel, Belg.). Nucl. Phys., 56: 394-400(Aug. 1964).

The angular distribution for the $T(d,n)^4He$ reaction was remeasured at 10° intervals from 0 to 130° for deuteron energies of 1 and 3 Mev. The calculated uncertainties are within ±2.0 and ±3.0%. The experimental results were fitted to Legendre polynomials and comparisons with earlier measurements are presented. (auth)

**28656** BRANCHING RATIOS OF RESONANCE LEVELS IN THE $Si^{28}$ NUCLEUS. Y. P. Antoufiev, D. A. E. Darwish, O. E. Badawy, L. M. El-Nadi, and P. V. Sorokin (Atomic Energy Establishment, Cairo). Nucl. Phys., 56: 401-14 (Aug. 1964).

The $^{27}Al(p,\gamma)^{28}Si$ reaction in the energy range from 1.6-2.5 Mev proton energy was investigated. Gamma spectra for ten resonances at $E_p = 1.669$, 1.680, 1.797, 1.917, 1.978, 2.054, 2.212, 2.312, 2.489, and 2.522 Mev were measured. Decay schemes and branching ratios for the corresponding resonance levels in the $^{28}Si$ nucleus were determined. (auth)

**28657** DETERMINATION OF DECAY ENERGY OF $^{153}Gd$. T. Cretzu, K. Hohmuth, and G. Winter (Zentralinstitut fur Kernforschung, Rossendorf, Ger.). Nucl. Phys., 56: 415-21(Aug. 1964). (In German)

In the $\gamma$ spectrum of the nucleus $^{153}Gd$ a 173-kev $\gamma$ transition was observed. Measurements were performed of the capture probabilities of K and L electrons for the transition to the 173-kev level in $^{153}Eu$. From these data the decay energy to this level was calculated to be 67.3 ± 2.0 kev. With a branching ratio of 17% one obtains $\log f_0 t = 5.84 \pm 0.08$. (auth)

**28658** ELASTIC SCATTERING OF DEUTERONS FROM THE CHROMIUM ISOTOPES. P. T. Andrews (Univ. of Liverpool), R. W. Clifft, L. L. Green, J. F. Sharpey-Schafer, and R. N. Maddison. Nucl. Phys., 56: 422-48(Aug. 1964).

The differential cross sections for the elastic scattering of deuterons from the four stable chromium isotopes were measured at energies between 7 and 11 Mev. The angular distributions obtained were analyzed using an optical model

parameter search program. Several distinct sets of deuteron parameters give equally good fits to a given angular distribution; it is shown that the difference between these sets is the number of half waves included inside the nuclear well. The effect of different parameterizations of the optical potential is examined and the variation of parameters over the small mass-energy range considered is discussed. (auth)

**28659** PROTON ELASTIC SCATTERING FROM THE CHROMIUM ISOTOPES. P. T. Andrews, R. W. Clifft, L. L. Green, and J. F. Sharpey-Schafer (Univ. of Liverpool). Nucl. Phys., 56: 449-64(Aug. 1964).

Differential cross sections for protons elastically scattered from isotopic chromium targets were measured using semiconductor counters. The data obtained were analyzed using an optical model parameter search program. The observed variation of the proton parameters with isotope is discussed. It is shown that there are at least two distinct proton potentials that give good agreement with the experimental data. (auth)

**28660** A STUDY OF THE $Cr^{52}(d,p)Cr^{53}$ REACTION. P. T. Andrews, R. W. Clifft, L. L. Green, and J. F. Sharpey-Schafer (Univ. of Liverpool). Nucl. Phys., 56: 465-90(Aug. 1964).

Angular distributions were measured in the $^{52}Cr(d,p)^{53}Cr$ reaction, using surface barrier counters and particle identification. The distributions are compared with the predictions of zero-range DWBA calculations using various sets of deuteron optical model parameters obtained from the elastic scattering of deuterons on $^{52}Cr$. The DWBA calculations are used to extract relative and absolute reduced widths for the states of $^{53}Cr$, and the variation of these widths with energy and with the set of deuteron parameters used is examined. (auth)

**28661** DECAY OF $Tc^{96}$. S. Shastry, B. B. Barman Roy, and R. Bhattacharyya (Saha Inst. of Nuclear Physics, Calcutta). Nucl. Phys., 56: 491-6(Aug. 1964).

The multipolarities of the different $\gamma$ rays of $^{96}Mo$ following the decay of the 4.3 d $^{96}Tc$ were measured from the internal conversion coefficients using the Siegbahn-Slätis $\beta$ spectrometer. The 317.2 and 1115-kev $\gamma$ rays were found to be of M1 and E2 characters, respectively. The $\gamma$-$\gamma$ angular correlation measurements were made employing the summing technique of Hoogenboom for the 317-1115 and 1115-841 kev cascades. (auth)

**28662** GAMMA RADIATION FROM THE ALPHA PARTICLE BOMBARDMENT OF $C^{12}$. J. D. Larson and R. H. Spear (California Inst. of Tech., Pasadena). Nucl. Phys., 56: 497-511(Aug. 1964).

The excitation function of the reaction $^{12}C(\alpha,\gamma)^{16}O$ was studied over the region $E_\alpha$ = 2.8 to 8.3 Mev using a NaI(Tl) detector and enriched $^{12}C$ targets. Resonances were observed at $E_\alpha$ = 3.24, 3.58, 4.26, 5.81, 7.05, 7.88, and 8.13 Mev, corresponding to $^{16}O$ states at $E_x$ = 9.59, 9.85, 10.36, 11.52, 12.45, 13.07, and 13.26 Mev. Radiative widths $\Gamma_\gamma$ for ground-state radiation from the states at 9.59, 9.85, 11.52, and 12.45 Mev were measured to be 0.022 ± 0.005, 0.0059 ± 0.0006, 0.66 ± 0.09 and 7 ± 1 ev. Radiative widths for cascade radiation from the 9.85 and 10.36-Mev states through intermediate states of $^{16}O$ were measured to be 0.0012 ± 0.0004 and 0.046 ± 0.006 ev. Interference effects in ground-state radiation from the 13.07-Mev ($1^-$) state support evidence for an underlying $2^+$ state at nearly the same energy. The excitation function for 4.43-Mev gamma radiation from the reaction $^{12}C(\alpha,\alpha'\gamma)^{12}C$ was studied over the region $E_\alpha$ = 7.5 to 10.5 Mev. Resonances were observed at $E_\alpha$ = 7.96, 8.14, 8.98, 10.08 (broad), and 10.20 Mev, corresponding to $^{16}O$ states at $E_x$ = 13.13, 13.27, 13.90, 14.72, and 14.81 Mev. (auth)

**28663** STUDY OF THE REACTION $B^{10}(d,t_0)B^9$. R. Fuelle, D. Netzband, and K. Schlott (Zentralinstitut fur Kernforschung, Rossendorf, Ger.). Nucl. Phys., 56: 512-17(Aug. 1964).

The absolute value of the differential cross section for the reaction $^{10}B(d,t_0)^9B$ was measured at a bombarding energy of 13.5 ± 0.1 Mev. The tritons were identified by means of the thin detector method combined with the dE/dx technique. By fitting a Butler curve to the angular distribution data values $r_0$ = 5.4 fm and $l_n$ = 1 were obtained. The absolute value of $d\sigma/d\Omega$ yields a reduced stripping width of $\Theta^2$ = 0.050 ± 0.010. Within the accuracy of measurement this value agrees with the stripping width of the reaction $^{10}B(n,d_0)^9Be$ and with the empirical single-particle width of $^{10}B$. (auth)

**28664** FOUR QUASI-PARTICLE EXCITATIONS AND TWO-PHONON VIBRATIONAL STATES IN SPHERICAL NUCLEI. [PART] I. M. Savoia (Università, Bologna and Istituto Nazionale di Fisica Nucleare, Bologna), J. Sawicki, and A. Tomasini, Nuovo Cimento (10), 32: 991-1014 (May 16, 1964).

A formalism is developed which presents a microscopic theory of both one- and two-phonon type vibrational states of spherical nuclei. The superconducting nature of nuclear structure is taken into account by the Bogoliubov canonical transformation. Two cases are considered: that of an uncorrelated ground state, and that of the ground-state correlations represented by a kind of second random phase approximation on the quasiparticles. Both the one- and the two-phonon type modes emerge as coherent superpositions of the two- and four-quasiparticle components. The respective eigenvalue equations and transition probabilities are discussed. (auth)

**28665** ISOTOPIC-SPIN CONSERVATION IN ALLOWED $\beta$-TRANSITIONS AND COULOMB MATRIX ELEMENTS. S. D. Bloom (CERN, Geneva). Nuovo Cimento (10), 32: 1023-36(May 16, 1964).

A survey was made of all available experimental data for atomic weight >20 yielding a value for $|M_F|$, the Fermi matrix element, in allowed transitions. Useful measurements exist for 15 radionuclides. From $|M_F|$ are deduced the values of $|\alpha_T(T-1)|$, the absolute value of the impurity coefficient for isotopic spin (T) in state (T − 1), and of $|\langle H_C\rangle|$, the effective Coulomb matrix element. In deducing $|\langle H_C\rangle|$, recent results on (p,n) reactions joining isobaric states in medium and heavy nuclei were used to locate the T-state excitation. There is a marked tendency for $|\alpha_T(T-1)|$ to be $\lesssim 5\times10^{-3}$ ($\alpha^2 \lesssim 3\times10^{-5}$ and for $|\langle H_C\rangle|$ to be ≲30 kev. Four measurements yield values higher than these limits, but in three of these alternative experimental results give values which are lower. The fourth measurement is the $^{64}Ga$ ($0^+ \rightarrow 0^+$) transition which gives one of the biggest and most precise values for $\alpha_T(T-1)$, $(2.00 \pm 0.05)\times10^{-2}$. However, this deduction depends on the spin assignment for $^{64}Ga$, expected to be 1 from shell-model theory. The general findings described above are in good qualitative accord with the results of a previous survey of $\alpha_T(T-1)$ in light nuclei ($A \lesssim 20$). It is therefore suggested that $|\langle H_C\rangle|$ tends to be ≲30 kev in the vicinity of the ground state (≲5 Mev excitation) as a general rule for all atomic weights up to at least 134. This is in keeping with the finding from the above-mentioned (p,n) reactions that isospin is (qualitatively) well conserved for all atomic weights at low excitations (≲10 Mev). (auth)

**28666** STATISTICAL-MODEL CALCULATION FOR NEUTRON-INDUCED REACTIONS. G. S. Mani and I. Iori (Centre d'Etudes Nucleaires, Saclay, France). Nuovo Cimento (10), 32: 1092-1102(May 16, 1964).

Using nuclear penetrabilities generated by an optical-model potential, the reaction cross sections for (n,p) and (n,$\alpha$) reactions were computed for all nuclei from sodium to mass 120 and compared with experiment. A comparison is also made between Cameron's and Erba's level density formulas. (auth)

**28667** THE POLARIZATION OF PROTONS FROM $^{12}C(d,p)^{13}C$ REACTION. F. Asfour, I. Bondouk, V. J. Gontchar, V. A. Loutsik, F. Machali, and I. I. Zaloubovsky (Atomic Energy Establishment, Cairo). Nuovo Cimento (10), 32: 1107-9(May 16, 1964).

Proton polarization from the reaction $^{12}C(d,p)^{13}C$ was measured at deuteron energy of 1.06 Mev and at five angles (30, 50, 90, 120, and 150°), using $^{7}Li(p,\alpha)^{4}He$ as the analyzing reaction. Polarization varied slightly with emission angle, with a maximum of about 31% at 30°. Results are compared with those from other experiments. (M.J.T.)

**28668** NUCLEAR ORIENTATION OF $Ir^{191m}$ IN IRON. J. A. Cameron, I. A. Campbell, J. P. Compton, and R. A. G. Lines (Oxford Univ.). Phys. Letters, 10: 24-5(May 15, 1964).

The isomer $^{191m}Ir$ was aligned in iron at low temperatures. A large anisotropy observed for the 129-kev gamma was investigated. The $^{191m}Ir$ magnetic moment and relaxation time were also determined. (C.E.S.)

**28669** ENERGY PARTITION OF PAIR ELECTRONS PRODUCED IN PLATINUM BY 5-90 Mev X-RAYS. R. R. Roy (Arizona State Univ., Tempe). Phys. Letters, 10: 74-5(May 15, 1964).

The energy partition of electron pairs produced in platinum by a hardened x-ray beam of 5 to 90 Mev was investigated. The platinum target was in the shape of a wire grid and embedded inside a nuclear emulsion. Experimental results were compared with theoretical predictions. (C.E.S.)

**28670** TOTAL CROSS SECTION OF THE REACTION $B^{10}(He^{3},t)C^{10}$ BETWEEN THRESHOLD AND 10.5 Mev. D. R. Osgood, J. R. Patterson, and E. W. Titterton (Australian National Univ., Canberra). Phys. Letters, 10: 75-6(May 15, 1964).

The total cross section of the reaction $^{10}B(^{3}He,t)^{10}C$ was determined for the energy range from threshold to 10.5 Mev. Properties of the reaction were compared with previous data for the $^{10}B(p,n)^{10}C$ reaction. (C.E.S.)

**28671** THE $g_R$-FACTOR OF THE $2^+$ ROTATIONAL STATE OF YTTERBIUM 172. C. Guenther, W. Engels, and E. Bodenstedt (Universität, Bonn). Phys. Letters, 10: 77-9(May 15, 1964).

The $g_R$-factor of the 79-kev $2^+$ rotational state of $^{172}Yb$ was investigated by rotating a $\gamma\gamma$-angular correlation in an external magnetic field. The 1095 to 79-kev $\gamma\gamma$ cascade in the decay of $^{172}Lu$ was investigated. (C.E.S.)

**28672** SEARCH FOR $Li^{7}(n,\alpha)H^{4}$ REACTION WITH 14 Mev NEUTRONS. R. V. Popić, B. Z. Stepančić, and N. R. Aleksić (Inst. of Nuclear Sciences "Boris Kidric," Belgrade). Phys. Letters, 10: 79-80(May 15, 1964).

The upper limit of the production cross section for $^{4}H$ was determined for the $^{7}Li(n,\alpha)^{4}H$ reaction at 14 Mev. No experimental evidence was found for the existence of stable $^{4}H$. (C.E.S.)

**28673** NOTE ON THE $Y_{40}$ DEFORMATION IN HEAVY NUCLEI. K. Harada (Univ. of California, Berkeley). Phys. Letters, 10: 80-2(May 15, 1964). (UCRL-11234)

Perturbation theory is used to calculate the $Y_{40}$ deformation in the alpha decay rates of isotopes of Ra, Th, U, Pu, Cf, and Cm. (C.E.S.)

**28674** DIRECT RADIATIVE CAPTURE OF PROTONS INTO THE LOWEST ODD-PARITY STATES OF $N^{14}$. W. Trost, H. J. Rose, and F. Riess (Universität, Freiburg i. B.). Phys. Letters, 10: 83-5(May 15, 1964).

Gamma radiation from the direct capture of protons in $^{14}N$ at 2.435 Mev were investigated to obtain evidence that the protons were captured into the lowest odd-parity states of $^{14}N$. The energy, assignments, cross sections, and anisotropies of the gamma rays were tabulated. (C.E.S.)

**28675** VARIATION OF THE STRENGTH FUNCTION WITH THE SPIN VALUE. J. Julien, G. Bianchi, C. Corge, V.-D. Huynh, G. Le Poittevin, J. Morgenstern, F. Netter, and C. Samour (CEN, Saclay, France). Phys. Letters, 10: 86-8(May 15, 1964).

Neutron inelastic resonance scattering on nuclei with mass number around 75 was studied in order to deduce a value of the strength function valid for the two families of spin $I \pm \frac{1}{2}$ of the composite nucleus. Different values of the strength functions for each spin family are summarized for gallium-69, arsenic-75, selenium-77, and platinum-195, and, where the statistical sample is valid, the probability is given of finding a ratio of the strength functions of the two possible spin states equal to or greater than that observed. It is evident that, for nuclei around mass number 75, the strength function is dependent on the spin. (M.J.T.)

**28676** THE TWO-STAGE REACTION $C^{12}(pp')C^{12*}(\alpha)Be^{8}$. G. D. Symons (California Inst. of Tech., Pasadena). Phys. Letters, 10: 89-90(May 15, 1964).

A previous study of the reaction $^{12}C(p,\alpha)^{9}B$ is discussed, and evidence is presented to show that this alpha group arises from the two-stage reaction $^{12}C(p,p')^{12*}C(\alpha)^{8}Be$ proceeding through the 9.64-Mev state of $^{12}C$. The proton bombarding energies used were 11.0, 11.4, 11.87, and 12.5 Mev. (C.E.S.)

**28677** STUDY OF THE $\alpha$ EMISSION OF THE SERIES $Ac^{224} \rightarrow Fr^{220} \rightarrow At^{216} \rightarrow ThC$. J. P. Briand and M. Lefort (Faculté des Sciences, Paris). Phys. Letters, 10: 90-2 (May 15, 1964). (In French)

Experiments using direct alpha spectrography, alpha spectrography with sources prepared by recoil, and gamma-alpha coincidence were employed for the investigation of the $\alpha$ emission of the $^{224}Ac \rightarrow ^{220}Fr \rightarrow ^{216}At$ series. The existence of an $\alpha$ fine structure for these nuclides is demonstrated. Energies and relative intensities of the principal fine-structure lines are presented. (M.J.T.)

**28678** THE $3^+$ STATE IN $O^{18}$. P. Hewka, R. Middleton, and J. Wiza (Univ. of Pennsylvania, Philadelphia). Phys. Letters, 10: 93-5(May 15, 1964).

A study of the $^{17}O(d,p)^{18}O$ reaction was made at an energy of 10 Mev, and the angular distribution of several proton groups were measured. The data are considered along with previous results from the $^{16}O(t,p)^{18}O$ reactions, and the identification of the $3^+$ state arising from the $(d^{5}/_{2}\ S^{1}/_{2})$ configuration is made. (C.E.S.)

**28679** FINITE RANGE INTERACTION EFFECTS FOR THE ($\alpha$, NUCLEON) REACTION. T. G. Kelley (Univ. of Washington, Seattle and Oregon State Univ., Corvallis) and

E. M. Henley. Phys. Letters, 10: 95-9(May 15, 1964). (TID-20559)

It is shown that the difference in the structure of the interaction that causes stripping and knock-out in the $(\alpha,N)$ reaction leads to measurable differences in the polarization of the outgoing nucleon. Initial results obtained for the $^{12}C(\alpha,p)^{15}N$ and $^{13}C(\alpha,n)^{16}O$ reactions at 20 and 40 Mev are reported. The differences between stripping and knock-out appear to be measurable at the higher energy. (C.E.S.)

**28680** THE (p,α) REACTION FOR p-SHELL NUCLEI AND REDUCED WIDTHS FOR NUCLEON CLUSTERS. T. Honda (Tohoku Univ., Sendai), Y. Kudo, H. Ui, and H. Horie. Phys. Letters, 10: 99-102(May 15, 1964).

The $^{16}O(p,\alpha)^{13}N$ reaction at 18.1 Mev and the $^{15}N(p,\alpha)^{12}C$ reaction at 15.16 Mev are analyzed in terms of both the pick-up and heavy-particle stripping reactions by means of the relevant reduced widths calculated from the L-S coupling shell model. (C.E.S.)

**28681** A FINAL STATE INTERACTION MODEL FOR THE PHOTODISINTEGRATION OF THE $C^{12}$ INTO THREE α-PARTICLES. J. Letessier (Faculte des Sciences, Bordeaux). Phys. Letters, 10: 102-4(May 15, 1964).

Results concerning the role of the final state interactions in phenomena associated with $^{12}C$ photodisintegration into three alpha particles are reported. An attempt is made to determine whether previously proposed models can be used for interpreting the experimental results concerning the phenomena. (C.E.S.)

**28682** AN EXPERIMENTAL TEST FOR THE NATURE OF FLUCTUATIONS IN THE REACTION CROSS SECTIONS. P. Strohal, P. Kulišić, Z. Kolar, and N. Cindro (Inst. "Ruder Boskovic," Zagreb). Phys. Letters, 10: 104-6 (May 15, 1964).

An attempt is made to find more evidence for the existence of fluctuations in the total cross sections of neutron induced reactions and to establish the A-dependence of the period of fluctuations and their amplitude dependence on the number of final states. Fine resolution measurements of the total cross sections for the reactions $^{19}F(n,2n)^{18}F$, $^{24}Mg(n,p)^{24}Na$, and $^{56}Fe(n,p)^{56}Mn$ are reported for neutron energies around 14 Mev. (C.E.S.)

**28683** THE LOCAL ENERGY APPROXIMATION TO NONLOCALITY AND FINITE RANGE EFFECTS. F. G. Perey (Oak Ridge National Lab., Tenn.) and D. S. Saxon. Phys. Letters, 10: 107-9(May 15, 1964).

The local energy approximation that can be applied to calculations of the nonlocal optical and shell model potentials and finite range effects in the distorted wave theory of transfer reactions is discussed. (C.E.S.)

**28684** DETERMINATION OF THE NEUTRON-NEUTRON SCATTERING LENGTH. V. K. Voitovetskii, I. L. Korsunskii, and Y. F. Pazhin (Kurchatov Inst. of Atomic Energy, Moscow). Phys. Letters, 10: 109-12 (May 15, 1964).

Investigation of nuclear reactions resulting in production of particles having low energy of relative motion may be used to determine quantities that are characteristic for the interaction of these particles. An experiment of this type was carried out for the determination of the neutron-neutron scattering length. The proton spectrum at the upper boundary in the D(n,p)2n reaction at 13.9 Mev was investigated. The neutron scattering length was determined to be $\sim -23.6$ fm. (C.E.S.)

**28685** THE LIFETIME OF THE 820 kev STATE OF $In^{115}$. P. N. Tandon and H. G. Devare (Tata Inst. of Fundamental Research, Bombay). Phys. Letters, 10: 113-14 (May 15, 1964).

The lifetime of the 820-kev state of $^{115}In$ was investigated by means of beta-gamma coincidences in the decay of $^{115}Cd$. A previously reported value of this lifetime was found to be in error. (C.E.S.)

**28686** ANGULAR DISTRIBUTION OF POLARIZATION OF PROTONS SCATTERED ELASTICALLY AT CARBON AT SEVERAL ENERGIES BETWEEN 6.0 AND 6.8 Mev. P. Bém, J. Habanec, J. Němec, O. Karban, and V. Presperin (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez). Phys. Letters, 10: 114-15(May 15, 1964).

The angular distribution of polarization of protons elastically scattered from carbon was measured at six energies between 6.0 and 6.8 Mev in 5-degree intervals for scattering angles of 30 to 140°. The energy dependence of the angular distribution of polarization was shown. (C.E.S.)

**28687** THE POLARIZATION OF PHOTONEUTRONS FROM $Be^9$ FOR $E\gamma = 2.75$ Mev. E. G. Corman, R. W. Jewell, W. John, J. E. Sherwood, and D. White (Univ. of California, Livermore). Phys. Letters, 10: 116-17 (May 15, 1964). (UCRL-7789)

The polarization of photoneutrons from the reaction $^9Be(\gamma,n)$ was measured by using the 2.753-Mev gamma ray of $^{24}Na$. Evidence was found for a small forward peaking of the neutrons. The results were compared with previous theoretical models. (C.E.S.)

**28688** NUCLEAR LEVELS OF EVEN Sn ISOTOPES POPULATED IN THE DECAY OF In ISOMERS. J. Kantele and M. Karras (Univ. of Arkansas, Fayetteville). Phys. Rev., 135: B9-21(July 13, 1964).

The decay of the following neutron-rich indium isomers produced by 14-15-Mev neutron bombardments of isotopically enriched tin samples were studied with beta and gamma scintillation techniques: 5.0 ± 0.5-sec and 4.35 ± 0.05-min $^{118}In$, 3.2 ± 0.4- and 44.3 ± 1.5-sec $^{120}In$, and 7.5 ± 0.8 sec-$^{122}In$. The disintegration of the 3.5-min $^{118}Sb$ isomer was investigated by using a highly mass-separated $^{118}Te$ source. Numerous levels in the corresponding tin isotopes were found to be populated, and the level schemes are compared with the theoretical calculations of Kisslinger and Sorensen and of Arvieu. The systematics of odd-odd In isomers are discussed in light of the spectroscopic data and the nuclear-shell model. The isomeric cross-section ratios of the (n,p) reaction forming the $^{116}In$, $^{118}In$, and $^{120}In$ isomers were measured and are briefly discussed. (auth)

**28689** CONSERVATION OF PARTICLE NUMBER IN THE NUCLEAR PAIRING MODEL. Klaus Dietrich, Hans J. Mang, and Jean H. Pradal (Univ. of California, Berkeley). Phys. Rev., 135: B22-34(July 13, 1964). (UCRL-11083)

The Euler-Lagrange equations corresponding to a Bardeen-Cooper-Schrieffer (BCS) state that is an eigenstate of the number operator are derived and solved numerically for a δ interaction. The errors due to the nonconservation of particle number in the usual BCS theory are studied as a function of particle number, level density, and strength of the pairing interaction. A proof is given that for attractive pairing interactions the lowest energy solution corresponds always to a real positive probability amplitudes. (auth)

**28690** SEPARABILITY OF CENTER-OF-MASS MOTION IN THE NUCLEAR SHELL MODEL. M. A. Nagarajan (Case Inst. of Tech., Cleveland). Phys. Rev., 135: B34-6(July 13, 1964).

It is shown that an orthogonal transformation can be

found that will split the motion of a many-body system into a center-of-mass motion and an internal motion. A particular orthogonal transformation was chosen which retains the independent-particle aspect of a harmonic-oscillator shell-model Hamiltonian. It is suggested that the states with spurious motions of the center of mass could be easily studied and eliminated by a direct transformation of the shell-model wave function into the new coordinate system. (auth)

**28691** DECAY OF $Rb^{90}$. Noah R. Johnson, G. D. O'Kelley, and E. Eichler (Oak Ridge National Lab., Tenn.). Phys. Rev., 135: B36-43(July 13, 1964).

Following the neutron irradiation of uranyl stearate, $^{90}Rb$ sources were obtained by decay of the emanated $^{90}Kr$. The decay properties of $^{90}Rb$ were then investigated with scintillation techniques. From single-crystal and gamma-gamma coincidence spectra, gamma rays (and intensities) were found at energies of 0.53(6.6), 0.72(6.5), 0.832(90), 0.86(10), 1.03(6.0), 1.11(13), 1.24(4.3), 1.40(8.3), 1.70(6.1), 1.82(4.8), 2.20(3.6), 2.51(5.6), 2.72(1.8), 2.84(3.0), 3.07(9.7), 3.34(28), 3.54(12), 4.13(20), 4.34(24), 4.37(7.8), 4.60(8.4), 5.08(3.0), and 5.23(6.7) Mev. Also, from single-crystal and beta-gamma coincidence spectra, beta groups were observed with energies of 1.31, 2.0, 2.2 (complex), 4.37, 5.81, and 6.60 Mev, where the last group represents the separation between the $^{90}Rb$-$^{90}Sr$ ground states. A decay scheme is proposed for $^{90}Rb$. The half-lives of $^{90}Rb$ and $^{91}Rb$ were remeasured as 2.91 ± 0.05 and 1.17 ± 0.10 min, respectively. (auth)

**28692** ENERGY LEVELS OF $Tl^{208}$ AND $Bi^{208}$. Yeong E. Kim (Bell Telephone Labs., Murray Hill, N. J.) and John O. Rasmussen. Phys. Rev., 135: B44-51(July 13, 1964).

The low-lying energy levels of $^{208}Tl$ and $^{208}Bi$ are calculated by using the j-j coupling shell model and a residual Gaussian potential of Kim and Rasmussen, which was used in the shell-model calculation of $^{210}Bi$ and $^{210}Po$. The eigenvalues and eigenfunctions are presented and compared with experimental spectra. The calculated results agree rather well with available experimental data and indicate that inclusion of the tensor force in the shell-model residual force is necessary in explaining the energy-level spectra of $^{208}Tl$ and $^{208}Bi$. (auth)

**28693** EXCITED-STATE SPIN ASSIGNMENTS BASED ON (n,γγ) ANGULAR-CORRELATION MEASUREMENTS ON MEDIUM-WEIGHT NUCLEI. R. E. Coté, H. E. Jackson, Jr., L. L. Lee, Jr., and J. P. Schiffer (Argonne National Lab., Ill.). Phys. Rev., 135: B52-6(July 13, 1964).

The angular correlations of cascade gamma rays were measured for $^{45}Ca$, $^{55}Fe$, $^{59}Ni$, $^{61}Ni$, and $^{63}Ni$ formed by thermal-neutron capture. The observation of large anisotropies allows an unambiquous assignment of $J^\pi = 3/2^-$ to be made for states at excitations of 2.24 Mev in $^{45}Ca$, 0.870 Mev in $^{59}Ni$, and 0.158 and 0.526 Mev in $^{63}Ni$, all of which exhibit an l = 1 stripping pattern in (d,p) reactions. The data for the l = 1 levels at 0.413 Mev in $^{55}Fe$, 0.470 Mev in $^{59}Ni$, and 0.284 Mev in $^{61}Ni$ indicate isotropy to within statistical errors of less than 1.5%, a result that is consistent with an assignment of $J^\pi = 1/2^-$ for these levels. The levels at 1.310 Mev in $^{59}Ni$ and 1.008 Mev in $^{63}Ni$ were also assigned $J^\pi = 1/2^-$ on the basis of an observed isotropy, although this assignment is somewhat uncertain because the statistical errors are about 12 and 7%, respectively. The results definitely show that the alleged separation of levels associated with the $p_{3/2}$ and $p_{1/2}$ gross-structure groups is incomplete; J = 1/2 levels exist within the $p_{3/2}$ group. (auth)

**28694** ANGULAR AND ENERGY CORRELATIONS IN THE REACTION $O^{16}(\alpha,2\alpha)C^{12}_{g.s.}$ AT 40-Mev INCIDENT ALPHA-PARTICLE ENERGY. P. F. Donovan (Bell Telephone Labs., Murray Hill, N. J. and Brookhaven National Lab., Upton, N. Y.), J. V. Kane, Č. Zupančič, C. P. Baker, and J. F. Mollenauer. Phys. Rev., 135: B61-75(July 13, 1964). (BNL-7417)

The correlations in energy and angle of alpha particles produced in the reaction $^{16}O(\alpha,2\alpha)^{12}C_{g.s.}$ were measured. Coincidence techniques were employed using semiconductor particle detectors and two-dimensional pulse-height analysis. The data show that a two-step reaction mechanism involving the formation and decay of excited states of $^{16}O$ plays an important role. However, direct knock-out features of the reaction are also prominent and appear to be inextricably interwoven with its two-step aspects. (auth)

**28695** ELASTIC AND INELASTIC SCATTERING OF FAST NEUTRONS FROM Co, Cu, AND Zn. A. B. Smith, C. A. Engelbrecht, and D. Reitmann (Argonne National Lab., Ill.). Phys. Rev., 135: B76-82(July 13, 1964).

Cross sections and angular distributions were measured for the elastic and the inelastic scattering of neutrons from natural Co, Cu, and Zn to 1.5 Mev. The measured values are compared with the results of optical-model calculations using spin assignments which are either known or are consistent with shell-model predictions. The effect of resonance width fluctuations is investigated. The theoretically calculated elastic scattering angular distributions are in good agreement with the experimental cross sections. Theoretical consideration of resonance width fluctuations tends to result in better agreement with the measured Cu inelastic cross sections. (auth)

**28696** $Fe^{54}(d,p)Fe^{55}$ REACTION AND THE NUCLEAR STRUCTURE OF $Ti^{51}$, $Cr^{53}$, AND $Fe^{55}$. James R. Maxwell and W. C. Parkinson (Univ. of Michigan, Ann Arbor). Phys. Rev., 135: B82-90(July 13, 1964).

The energy levels in $^{55}Fe$ were investigated by means of the $^{54}Fe(d,p)^{55}Fe$ reaction at 7.8 Mev. Twenty-eight levels were found up to 5.4 Mev of excitation, and angular distributions were obtained for eighteen of them. The $l_n$ values and reduced widths were extracted from the data by means of a distorted-wave Born-approximation analysis. An attempt is made to understand the spectra of $^{51}Ti$, $^{53}Cr$, and $^{55}Fe$ in terms of a shell-model description involving configurations of 2, 4, or 6 ($1f_{7/2}$) protons and a single neutron in the $2p_{3/2}$, $2p_{1/2}$, or $1f_{7/2}$ orbit. (auth)

**28697** PHENOMENOLOGICAL POTENTIALS AND THE D(n,p)2n REACTION. D. R. Koehler (Army Missile Command, Redstone Arsenal, Ala.) and R. A. Mann. Phys. Rev., 135: B91-8(July 13, 1964).

The D(n,p)2n reaction is treated in a direct interaction framework in which the phenomenological N-N potentials of Gammel and Thaler are used to describe the perturbation interactions. Tensor forces as well as central forces are included, and final-state interactions among the particles are considered. The final state is pictured as a continuum deuteron plus free neutron or as a continuum dineutron plus free proton. To the extent that this picture is accurate, it is found that the main contributions to the cross section are supplied by the doublet to doublet transitions. The calculations furthermore suggest a "best choice" for the triplet — even parity — central potential. A comparison with the experimental results of Ilakovac and co-workers at 14.4 Mev is presented. (auth)

**28698** NEUTRON-ALPHA SCATTERING IN THE 20-Mev RANGE. R. E. Shamu and J. G. Jenkin (Australian

National Univ., Canberra). Phys. Rev., 135: B99-109 (July 13, 1964).

The angular distributions of neutrons scattered by alpha particles at 16 to 26 Mev were measured by observing the recoiling alpha particles in a high-pressure gas scintillator. Above 22 Mev, disintegration particles from the $^4$He(n,d)T reaction were also observed. Data were taken in 25-kev steps over the $^5$He state at 16.7-Mev excitation energy (22.15-Mev neutron energy) and over the $^4$He(n,np)T, $^4$He(n,n′)$^{4*}$He, and $^4$He(n,2n)$^3$He thresholds. Total cross sections of helium were measured at 26 energies from 20- to 29-Mev neutron energy in a good geometry transmission experiment. The angular distributions at neutron energies <24 Mev were fitted with expansions of Legendre polynomials. Polynomials of order 0 through 4 provided a satisfactory fit. Below 22 Mev, the angular distributions agree with calculations based on n-α phase shifts suggested by Perkins. Above 22 Mev, the agreement is not as good. The total cross sections agree only qualitatively with these calculations. The total cross section and angular distribution data are consistent with a $\frac{3}{2}^+$ assignment for the 16.7-Mev level. The measured yield curve for the $^4$He(n,d)T reaction agrees with that computed from the cross section for the inverse reaction. (auth)

**28699** LEVEL STRUCTURE OF $Bi^{208}$ AS OBSERVED AT HIGH RESOLUTION WITH THE $Bi^{209}(d,t)Bi^{208}$ REACTION. John R. Erskine (Argonne National Lab., Ill.). Phys. Rev., 135: B110-15(July 13, 1964).

The $^{209}$Bi(d,t)$^{208}$Bi reaction was studied at 12 Mev with a high-resolution magnetic spectrograph. A ground-state Q value of −1.201 ± 0.005 Mev was measured. Excited states were observed at 0.063, 0.513, 0.605, 0.634, 0.651, 0.890, 0.929, 0.963, 1.074, 1.098, 2.349, 2.394, and 2.417 Mev. The angular-distribution data taken separate the $h_{9/2}p_{1/2}^{-1}$ states from the $h_{9/2}f_{5/2}^{-1}$ states. Spin assignments based on the observed cross sections of the levels are given. In particular, the ground state and first excited state are assigned J = 5 and J = 4, respectively. The resulting interpretation is in good agreement with the $^{208}$Bi calculations by Kim. (auth)

**28700** ALPHA-PARTICLE SCATTERING BY $P^{31}$ AT 18.2 Mev. B. T. Lucas, S. W. Cosper, and O. E. Johnson (Purdue Univ., Lafayette, Ind.). Phys. Rev., 135: B116-21(July 13, 1964).

The differential cross sections for the inelastic (1.265- and 2.232-Mev states) and elastic scattering of 18.2-Mev alpha particles from vacuum-evaporated phosphorous targets were measured using silicon surface-barrier detectors. The measurements were made at 2.5° intervals in the nominal angular range from 10 to 173°. All the angular distributions exhibit an oscillatory diffraction-like structure with rather uniformly spaced maxima for angles less than about 90°. In each angular distribution the oscillatory behavior persists to backward angles, but becomes less distinct and regular. The elastic cross section increases rapidly at extreme backward angles, a behavior exhibited to a lesser degree by the inelastic cross sections. Analyses of the ground-state angular distribution were made in terms of the simple diffraction model, yielding R = 6.28 F and the sharp-cutoff Akhieser-Pomeranchuk-Blair model, yielding $l_0 = 9$. A graphical compilation of experimental elastic alpha-particle angular distributions for a series of light nuclei corresponding to incident alpha energies in the range from 18.0 to 22.5 Mev is presented, and the possible existence of a systematic difference in the backward-angle behavior of the cross sections for certain even-even and odd-A nuclei is discussed. A Blair diffraction-model analysis of the inelastic angular distribution associated with the 2.232-Mev state resulted in the following values for the collective-model parameters: $C_2/(C_2)_{irrot} = 7.9$ and $B_2/(B_2)_{irrot} = 50$ assuming a pure vibrational transition; and $|\beta_2| = 0.13$ assuming a pure intra-band rotational transition with $K = \frac{1}{2}$. The inelastic angular distributions associated with the 1.265- and 2.232-Mev states were analyzed using the direct-interaction theories of Austern and McCarthy. Satisfactory fits were obtained at forward angles for both angular distributions with $j_2^2(QR)$ using R = 6.52 F, and with the expressions of McCarthy using R = 6.62 F, λ = 1.0 F, and γ = 0.8. (auth)

**28701** FORMATION OF SODIUM AND POTASSIUM NUCLIDES IN THE BOMBARDMENT OF LIGHT ELEMENTS WITH 29-Gev PROTONS. Norbert T. Porile and Shigeo Tanaka (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 135: B122-8(July 13, 1964). (BNL-7633)

The cross sections for the production of $^{22}$Na, $^{24}$Na, $^{42}$K, and $^{43}$K from Ti, Fe, and Cu targets at 29 Bev were measured. The recoil properties of $^{24}$Na and $^{42}$K were investigated by thick-target, integral-range measurements. The formation cross sections decrease slightly with increasing mass difference between target and product, the values for $^{24}$Na ranging from 4.2 ± 0.3 mb for Ti to 3.5 ± 0.3 mb for Cu. The effective ranges, FW and BW (the fraction of fragments recoiling into the forward and backward catchers times the target thickness, respectively), vary with mass difference in the opposite way. The values of FW for $^{24}$Na in Ti, Fe, and Cu thus are 0.49, 0.66, and 1.00 mg/cm$^2$. The results of both types of measurements are compared with Monte Carlo cascade-evaporation calculations. While the cross sections are in good agreement with calculation, the effective ranges are not; the discrepancy indicates that the cascade calculation probably overestimates the forward component of velocity of the residual nuclei. The average effective ranges, ½(FW + BW), are in good agreement with evaporation calculations. This agreement, as well as that of the cross-section data, indicates that the spallation process can account for these experimental results. (auth)

**28702** TOTAL GAMMA ABSORPTION IN $Be^9$, $O^{16}$, $F^{19}$, AND $Al^{27}$ AT 20 Mev. George Tessler and W. E. Stephens (Univ. of Pennsylvania, Philadelphia). Phys. Rev., 135: B129-36(July 13, 1964).

The total gamma absorption cross sections were measured for $^9$Be from 20.04 to 21.24 Mev, $^{16}$O from 20.37 to 22.04 Mev, $^{19}$F from 19.97 to 20.46 Mev, and $^{27}$Al from 20.37 to 20.88 Mev using monochromatic gamma rays from the $^3$T(p,γ)$^4$He reaction. The $^9$Be nuclear cross section showed structure at 20.47 ± 0.04 and 20.73 ± 0.04 Mev with integrated cross sections of 0.45 and 0.90 Mev-mb, respectively. The $^{16}$O nuclear cross section contained a broad peak at 21.02 ± 0.04 Mev with an integrated cross section of 10.4 Mev-mb. There is some indication that this peak is composed of two narrower peaks at about 20.86 and 21.05 Mev. There is also some indication of structure at 20.62 Mev. Above about 21.6 Mev, the $^{16}$O cross section is rising sharply, consistent with the giant resonance peak above 22 Mev. The $^{19}$F cross section has a peak at 20.09 ± 0.05 Mev with an integrated cross section of 3.5 Mev-mb. The $^{27}$Al cross section showed no structure in the energy region investigated. (auth)

**28703** SOLAR NEUTRINO CROSS SECTIONS AND NUCLEAR BETA DECAY. John N. Bahcall (California Inst. of Tech., Pasadena). Phys. Rev., 135: B137-46 (July 13, 1964).

The neutrino-producing reactions that are believed to

occur in the interior of the sun are reviewed, and the predicted neutrino fluxes from these reactions are presented. The relevant absorption cross sections for neutrino-induced transitions from the ground state of $^{37}$Cl to various states in $^{37}$Ar are then calculated. The nuclear model adopted in these calculations is also used to predict the decay rates and branching ratios for a number of nuclei with $1d^n_{\frac{3}{2}}$ configurations. Comparisons with experiment are made wherever possible, and additional tests are suggested. A method for extracting Gamow-Teller matrix elements from mixed transitions between members of the same isotopic multiplet is then illustrated. The theory of bound-state neutrino capture is also outlined and applied to the proposed solar neutrino experiment. Some neutrino cross sections that are useful in interpreting the reactor experiment of Davis are included. (auth)

**28704** HYPERFINE-STRUCTURE SEPARATIONS OF $Au^{191}$ AND $Au^{193}$. W. Bruce Ewbank and Howard A. Shugart (Univ. of California, Berkeley). Phys. Rev., 135: A358-61 (July 20, 1964). (UCRL-11129)

The hyperfine-structure separation in the $^2S_{\frac{1}{2}}$ electronic ground state was measured for two radioactive gold isotopes, $^{191}$Au and $^{193}$Au. Atomic-beam methods, after confirming that both nuclear spins are $I = \frac{3}{2}$, provided hfs separations of $\Delta\nu(^{191}Au) = \pm 5770(6)$ Mc and $\Delta\nu = \pm 5882(10)$ Mc. Combined with recent work on $^{197}$Au, these values give uncorrected nuclear-magnetic dipole moments of $\mu_I(^{191}Au) = \pm 0.136(7)$ nm, and $\mu_I(^{193}Au) = \pm 0.138(7)$ nm. Both measurements are consistent with the assignment of the unpaired proton in gold to a $d_{\frac{3}{2}}$ shell-model level. (auth)

**28705** T = 2 STATES IN $Mg^{24}$, $Ti^{44}$, AND $Fe^{52}$. Gerald T. Garvey (Princeton Univ., N. J.), Joseph Cerny, and Richard H. Pehl. Phys. Rev. Letters, 12: 726-8(June 29, 1964). (PUC-1964-145)

Experimental results for energy spectra from (p,t) reactions on $^{26}$Mg, $^{46}$Ti and $^{54}$Fe at 38.7 Mev are presented. Good agreement between the calculated and observed excitation energies of the lowest T = 2 states of $^{24}$Mg, $^{44}$Ti, and $^{52}$Fe is obtained. The states are sharp with much of the transition strength focused in a small energy interval. Thus it is proved as predicted that the (p,t) reaction does pick out states with $T = T_z + 2$ and these states lie near the energies expected from the Coulomb energy difference. (M.J.T.)

**28706** GEOMETRIC TEST OF THE ISOSPIN MULTIPLET NATURE OF NUCLEAR ANALOG STATES. S. Barshay and G. M. Temmer (Rutgers State Univ., New Brunswick, N. J.). Phys. Rev. Letters, 12: 728-33(June 29, 1964).

Possible incisive tests of isospin analogy are proposed, based on simple geometric properties of reaction cross sections. The tests apply equally well to ground and excited states of nuclei, from the lightest mirror pairs to the heaviest isobaric analogs. (M.J.T.)

**28707** DECAY OF $O^{16}$ GIANT DIPOLE STATES TO EXCITED STATES OF $O^{15}$. P. F. Yergin, R. H. Augustson, N. N. Kaushal, H. A. Medicus, W. R. Moyer, and E. J. Winhold (Rensselaer Polytechnic Inst., Troy, N. Y.). Phys. Rev. Letters, 12: 733-6(June 29, 1964).

The 90° photoneutron spectrum of $^{16}$O irradiated with bremsstrahlung of about 34-Mev end-point energy was measured. It is concluded that the giant dipole states in $^{16}$O decay strongly to one or both of the positive-parity states of $^{15}$O at 5.174 and 5.235 Mev. From the composite neutron spectrum, branching ratios are deduced. (M.J.T.)

**28708** ABSOLUTE DETERMINATION OF SPINS OF NEUTRON RESONANCES IN TERBIUM-159 BY A WEIGHTING FACTOR METHOD USING POLARIZED NEUTRONS AND A Tb-TARGET. H. Postma, F. J. Shore, and C. A. Reynolds (Brookhaven National Lab., Upton, N. Y.). Physica, 30: 713-28(Apr. 1964). (BNL-7347)

The spins of the lowest three neutron resonances in $^{159}$Tb were determined by transmission of polarized monochromatic neutrons through a sample containing polarized terbium nuclei. The spins were found to be $I + \frac{1}{2} = 2$, $I - \frac{1}{2} = 1$, and $I + \frac{1}{2} = 2$ respectively for the 3.35-, 4.99-, and 11.14-ev resonances. Ordinarily these assignments depend on the assumptions that the nuclear moment of $^{159}$Tb is positive, and that the effective field at the nucleus, due to the 4f electrons of $Tb^{3+}$, is parallel to the external polarizing field. However, the correctness of the combination of the given assignments is verified in an independent way, which uses the ratio of transmission effects measured at the three resonances. Approximate formulas for the transmission and the transmission effect are presented, which are of practical use for many resonances observed with neutron crystal spectrometers. (auth)

**28709** CROSS-SECTIONS FOR THE $^{115}In(n,n')^{115m}In$ REACTION. I. Heertje, W. Nagel, and A. H. W. Aten, Jr. (Instituut voor Kernphysisch Onderzoek, Amsterdam). Physica, 30: 775-8(Apr. 1964).

A cross-section curve is suggested for the reaction $^{115}In(n,n')^{115m}In$, based on the activation of indium with neutrons from a Ra-$\alpha$-Be source and with 14.6-Mev neutrons. (auth)

**28710** THE DECAY OF $^{184}$Ta. H. Verheul, J. Blok, H. G. Boddendijk, and G. H. Dulfer (Vrije Universiteit, Amsterdam). Physica, 30: 877-89(Apr. 1964).

The $\beta^-$ decay of $^{184}$Ta to the excited states of $^{184}$W was studied by means of scintillation spectrometers for $\beta$ and $\gamma$ rays. Coincidence experiments between the $\beta$ and $\gamma$ rays were performed to investigate the feeding of the levels. The highest excited state at 1550 kev can be interpreted as a two proton state. (auth)

**28711** PROTONS FROM THE ALPHA-PARTICLE BOMBARDMENT OF $^{31}$P. J. Kuperus (Rijksuniversiteit, Utrecht). Physica, 30: 899-904(Apr. 1964).

Resonances in the yield of ground-state protons from alpha-particle bombardment of $^{31}$P were investigated in the energy range $E_\alpha = 1.7 - 3.3$ Mev. Fourteen resonances were observed, none of which was known before. Resonance energies and strengths are presented. Angular distribution measurements lead to unique values of the resonance spin in all cases but one. The exception is the strong resonance at $E_\alpha = 3.302$ Mev, which shows a deviation from forward-backward symmetry in the angular distribution, to be explained by assuming interference with some unknown broad resonance with opposite parity, probably at higher energy. (auth)

**28712** DOPPLER EFFECT IN URANIUM-238 AT HIGH S/M VALUES. R. Sher (Stanford Univ., Calif.) and G. R. Pflasterer. Trans. Am. Nucl. Soc., 7: 27(June 1964).

**28713** EFFECTIVE RESONANCE INTEGRALS FOR URANIUM-238 OVER AN EXTENDED S/M RANGE. N. P. Baumann and D. J. Pellarin (E. I. du Pont de Nemours and Co., Aiken, S. C.). Trans. Am. Nucl. Soc., 7: 27-8(June 1964).

**28714** APPROXIMATE METHOD FOR DETERMINATION OF DOPPLER BROADENING OF PLUTONIUM-240 RESONANCES. R. L. Crowther (General Electric Co.,

San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 34-5(June 1964).

**28715** EPITHERMAL ALPHA OF URANIUM-235. D. E. Conway, H. D. Cook, and S. B. Gunst (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 78(June 1964).

**28716** EXPERIMENTAL STUDIES OF THE URANIUM-238 RESONANCE NEUTRON CAPTURE IN A NATURAL-URANIUM METAL CLUSTER CONTAINING MODERATING COOLANTS. B. Arcipiani, A. Boeuf, L. Haemers, and S. Tassan (Euratom, Ispra, Italy). Trans. Am. Nucl. Soc., 7: 83(June 1964).

**28717** MEASUREMENT OF RESONANCE ABSORPTION IN THORIUM-232 DIOXIDE/URANIUM-238 DIOXIDE MIXTURES. W. K. Foell (Phillips Petroleum Co., Idaho Falls, Idaho) and T. J. Connolly. Trans. Am. Nucl. Soc., 7: 84 (June 1964).

**28718** NEPTUNIUM-237 NEUTRON CROSS SECTIONS. David T. Goldman (Knolls Atomic Power Lab., Schenectady, N. Y.). Trans. Am. Nucl. Soc., 7: 84-5(June 1964).

**28719** BURNUP CROSS SECTIONS AND RESONANCE INTEGRALS OF DYSPROSIUM. J. J. Scoville, E. Fast, and J. W. Rogers (Phillips Petroleum Co., Idaho Falls, Idaho). Trans. Am. Nucl. Soc., 7: 85-6(June 1964).

**28720** MEASUREMENT OF THE RESONANCE-NEUTRON SELF SHIELDING IN GOLD WIRES. E. D. McGarry (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 86(June 1964).

**28721** LOW-ENERGY-LEVEL STRUCTURE OF URANIUM-233 WITH THE MULTILEVEL FORMALISM. F. T. Adler, D. B. Adler, and W. A. Goodwin (Univ. of Illinois, Urbana). Trans. Am. Nucl. Soc., 7: 86-7(June 1964).

**28722** DECAY OF MOLYBDENUM-99-TECHNETIUM-99m. P. Crowther and J. S. Eldridge (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 87-8(June 1964).

**28723** THERMAL POWER OF PROMETHIUM-147. J. C. Posey, R. S. Pressly, and J. H. Gillette (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 207-8 (June 1964).

**28724** EFFECT OF WEAK MAGNETISM ON BETA-RADIOACTIVITY. Eugene Greuling and Neal Huffaker (Duke Univ., Durham, N. C.). Trans. N. Y. Acad. Sci., 24: 591-602(Mar. 1962).

The term weak magnetism implies that there is some connection between magnetism and $\beta$ radioactivity, usually referred to by theorists as weak interactions. Moreover, a presentation is made of an elaboration of previous computed results valid for the theory of $\beta$ decay of heavy nuclei, nuclei for which it is not a good approximation to ignore either the existence of nuclear charge Ze or the magnitude of the nuclear radius, R. It is suggested that there is a very close analogy between the presently accepted form of the theory of $\beta$ decay and the well-established theory of electromagnetic interactions. A theoretical treatment of the relation is presented. (BBB)

**28725** THE ENERGY SPECTRA OF PHOTOPROTONS FROM $^{13}C$ AND $^{18}O$. R. Kosiek, K. Schluepmann, H. W. Siebert, and R. Wendling (Universität, Heidelberg). Z. Physik, 179: 9-15(1964). (In German)

The energy spectra of photoprotons from $^{13}C$ and $^{18}O$ were investigated with 31.5-Mev bremsstrahlung from the Heidelberg betatron using a CsI(Tl) spectrometer. The spectra were compared with those of $^{12}C$ and $^{16}O$. Yield values and cross sections are given. (auth)

**28726** DECAY SCHEMES, $\beta$ MATRIX ELEMENTS, AND $\gamma$ MULTIPOLE ORDER FOR THE TRANSITIONS $^{56}Co \rightarrow {}^{56}Fe$ AND $^{131}I \rightarrow {}^{131}Xe$. H. Daniel, O. Mehling, P. Schmidlin, D. Schotte, and E. Thummernicht (Max-Planck-Institut für Kernphysik, Heidelberg). Z. Physik, 179: 62-75(1964). (In German)

In the decay of $^{56}Co$ the following quantities were measured: $\gamma$ intensities, $\beta$-$\gamma$ directional correlation, and $\beta$-(circularly polarized $\gamma$) correlation. The directional correlation anisotropy was found to be, for $\beta$ energies above 300 kev, $A_2 = 0.5 \pm 0.4\%$, corresponding to small or vanishing twice forbidden contributions to the allowed decay. The asymmetry parameter A of the $\beta$-(circularly polarized $\gamma$) correlation was measured to be $A = -0.01 \pm 0.05$, which implies a ratio x between Fermi and Gamow-Teller contributions to the decay of $x = -0.10 \pm 0.07$, in agreement with the isospin selection rule. In the decay of $^{131}I$ the following quantities were measured: shape of the 606-kev $\beta$ group, $\gamma$ intensities, conversion coefficients, and $\beta$-(circularly polarized $\gamma$) correlations. The measured K/L ratio of the 364-kev $\gamma$ transition, $K/L = 6.0 \pm 0.2$, was compatible with the conversion tables of Sliv and Band only. The multipolarities of the $\gamma$ rays of 364, 637, and 723 kev were deduced. The 606-kev $\beta$-364-kev $\gamma$ cascade was used as a calibration standard for analysers of circularly polarized $\gamma$ rays. (auth)

**28727** $\alpha$-DECAY OF $Pu^{241}$. B. S. Dzhelepov, R. B. Ivanov, and V. G. Nedovesov. Zh. Eksperim. i Teor. Fiz., 46: 1517-24(May 1964). (In Russian)

The $\alpha$ spectrum of $^{241}Pu$ is studied with a magnetic $\alpha$ spectrometer with beam focusing at an angle $\pi\sqrt{2}$. The following $\alpha$ transitions were observed in the spectrum: 5042 (1.5%), 4973 (1.4%), 4899 (83%), 4862 (13%), and 4805 (1.1%) kev. The decay scheme of $^{241}Pu$ is discussed. (auth)

**28728** ON CONTRADICTORY RESULTS OF MEASUREMENTS OF THE $(\gamma,n)$-REACTION CROSS SECTION FOR LEAD. M. M. Dorosh, A. M. Parlag, V. A. Shkoda-Ulyanov, and L. A. Shabalina (Uzhgorod State Univ., USSR). Zh. Eksperim. i Teor. Fiz., 46: 1540-4(May 1964). (In Russian)

The experimental results of measurement of yields in heavy and intermediate (with respect to Z) elements in the low energy region are not in agreement with the results of calculations performed on basis of the Belenky–Tamm cascade theory. An experiment was carried out with the aim of measuring the $(\gamma,n)$ cross section in lead irradiated by bremsstrahlung since the data in the literature on the cross sections for some elements including lead are contradictory. The cross section at the maximum is 0.65 bn which is the same value as that of the cross section obtained for monochromatic $\gamma$ quanta. Comparison of the photoneutron yield calculated with the cross section thus obtained and the experimental data of Grizhko et al., confirms the discrepancy between theory and experiment. (auth)

**28729** SOME FEATURES OF THE DECAY OF HIGH ANGULAR MOMENTUM COMPOUND DYSPROSIUM NUCLEI. G. Kumpf and V. A. Karnaukhov (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1545-52(May 1964). (In Russian)

The energy dependences of the cross sections for the following reactions are measured: $^{116}Cd(^{40}Ar,7n)^{149}Dy$, $^{116}Cd(^{40}Ar,6n)^{150}Dy$, $^{116}Cd(^{40}Ar,5n)^{151}Dy$, $^{114}Cd(^{40}Ar,5n)^{149}Dy$, $^{114}Cd(^{40}Ar,4n)^{150}Dy$, $^{114}Cd(^{40}Ar,3n)^{151}Dy$. The excitation

functions have a shape characteristic of evaporation reactions. The experimental data are analyzed on basis of the generalized Jackson model (constant nuclear temperature) by taking into account rotation and restriction of possible spin values. The calculated excitation functions satisfactorily agree with the experimental values if the following parameter values are chosen: T = 3 Mev, $J_{cr}$ = 75 ħ (limiting angular momentum) and the moment of inertia of the compound nucleus is that of a rigid body. (auth)

**28730** ON THE POSSIBILITY OF STUDYING INTERFERENCE BETWEEN COULOMB AND NUCLEAR SCATTERINGS DURING THE COLLISIONS OF PARTICLES WITH ENERGIES ABOVE $10^{10}$ ev. V. A. Nikitin, V. A. Sviridov, L. N. Strunov, M. G. Shafranova (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1608-11(May 1964). (In Russian)

Two possible ways of measuring the elastic scattering cross section for particles with ultrahigh energies are considered. The methods are not limited by the energy from above and can be used for investigating elastic scattering in the region of low momentum transfer in which the Coulomb scattering cross section is comparable to the nuclear cross section. The methods, in particular, permit one to obtain information on the magnitude of the real part of the elastic scattering cross section by studying the interference effect between Coulomb and nuclear scatterings. (auth)

**28731** LARGE NUCLEAR DEFORMATIONS IN THE ANISOTROPIC OSCILLATOR MODEL. V. A. Belyakov. Zh. Eksperim. i Teor. Fiz., 46: 1632-6(May 1964). (In Russian)

The ground state energy, chemical potential, and gap magnitude in the energy spectrum of the even-even nuclei $^{86}$Kr, $^{88}$Sr, $^{90}$Sr, $^{136}$Ba, and $^{140}$Ce are calculated for large deformations on basis of the anisotropic oscillator model. (auth)

**28732** HYPERNUCLEI WITH TWO Λ PARTICLES AND THEIR DECAY. N. N. Kolesnikov and R. V. Vedrinskii (Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 46: 1648-52(May 1964). (In Russian)

The problem of existence of bound states of two Λ particles with nucleons is discussed, and on basis of global symmetry their binding energy is estimated. It is shown that the directions of meson emission during decay of such systems should be correlated. (auth)

**28733** INTERNAL CONVERSION COEFFICIENTS FOR STRONGLY FORBIDDEN γ-TRANSITIONS IN NUCLEI. L. A. Borisoglebskii (Belorussian State Univ., USSR). Zh. Eksperim. i Teor. Fiz., 46: 1664-76(May 1964). (In Russian)

Approximate analytic expressions for the electron factors at the nuclear parameters in the theory of internal conversion of strongly forbidden γ radiation are derived. The relation between the relative internal conversion coefficients and relative probabilities for EO-conversion in strongly forbidden γ transitions of nuclei is established. (auth)

**28734** NUCLEAR MAGNETIC MOMENTS. A. B. Migdal. Zh. Eksperim. i Teor. Fiz., 46: 1680-99(May 1964). (In Russian)

Expressions for the magnetic moments of nuclei are obtained by exactly taking into account the interaction between the nucleons. By comparing with experiment it is possible to determine the constants introduced in the theory and in particular the constant for spin-spin interaction between nucleons in the nucleus which is found to be the same for all spherical and deformed nuclei. A simple expression is obtained for the sum of the neutron and proton magnetic moments in identical states, and it satisfactorily agrees with experiment. With a good accuracy the theoretical values of the magnetic moments of the spherical nuclei coincide with the experimental values. The equations obtained can be employed for calculating nuclear magnetic form factors. (auth)

**28735** CAPTURE OF μ-MESONS BY THE $B^{10}$ NUCLEUS. G. M. Bukat and N. P. Popov (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Eksperim. i Teor. Fiz., 46: 1782-6(May 1964). (In Russian)

A formula for γν-correlation is obtained for allowed capture of μ-mesons by the $^{10}$B nucleus. Hyperfine splitting of levels of the mesic atom is taken into account. It is shown that γν-correlation during capture of nonpolarized μ-mesons is very sensitive to the pseudoscalar interaction contribution and weakly depends on the nuclear structure. (auth)

**28736** μ-MESON CAPTURE BY SPIN ½ POLARIZED NUCLEI. A. P. Bukhvostov and N. P. Popov (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Eksperim. i Teor. Fiz., 46: 1842-52(May 1964). (In Russian)

A formula is derived for the angular distribution of recoil nuclei produced in the capture of μ mesons by polarized spin ½ nuclei. Depolarization of the μ mesons and target nuclei due to interaction responsible for the fine as well as hyperfine structure is calculated. Asymmetry of the angular distribution of tritium nuclei due to μ-meson capture reaches 10%; for small values of the pseudoscalar form factor a term ~cos θ is predominant, whereas for $C_P/C_A \sim 30$ a term ~$P_2$ (cos θ) is predominant. (auth)

**28737** ON THE STRUCTURE OF COLLECTIVE EXCITATIONS OF SPHERICAL NUCLEI. V. G. Zelevinskii. Zh. Eksperim. i Teor. Fiz., 46: 1853-8(May 1964). (In Russian)

It is shown that for an oscillator with anharmonicity of the $x^{2n}$ type (of arbitrary strength) a simple transformation exists which appreciably improves the convergence of the perturbation theory series; the lower excited states in this case only slightly differ from those of an effective harmonic oscillator. This explains, in particular, the weak anharmonicity of the quadrupole oscillation spectrum of spherical even–even nuclei observed experimentally even though the interaction between the quadrupole phonons is sufficiently strong. (auth)

**28738** INTRINSIC QUADRUPOLE MOMENTS $Q_{½,½}$, $Q_{⅜,⅜}$, AND $Q_{½,⅜}$ IN $W^{183}$. F. Boehm and R. Brockmeier (California Inst. of Tech., Pasadena). p.340-2 of "Proceedings of the Uppsala Meeting on Extranuclear Perturbations in Angular Correlations," May 27-30, 1963. Amsterdam, North-Holland Publishing Co., 1964.

The electric quadrupole moments of the rotational bands in $^{183}$W were determined by analysis of the electromagnetic transition strengths for all the transitions between states in the K = ½ and ⅜ bands as well as for cross-band transitions. (D.C.W.)

**28739** A STUDY OF THE SCATTERING OF ACCELERATOR PRODUCED 1.09 Bev/C MUONS BY CARBON. Richard Owen Stenerson. Thesis, Seattle, Univ. of Washington, 1963. 192p.

The scattering cross section of high energy muons in carbon was measured. Beam design, measurement of beam properties, and the identification and rejection of

particles in the beam are discussed. Pions at beam momentum, which were the major contaminant, had a rejection relative to muons of $2.5 \times 10^{-6}$. The beam had a median momentum of 1.09 Bev/C and a spread of ~0.07 Bev/C. A spark chamber consisting of two sections of six gaps each separated by the 43.9 gm/cm$^2$ carbon target was used to observe the muon scatterings. Events measured had laboratory scattering angles in range from 10 to 40°. This corresponds to elastic momentum transfers from ~200 to ~550 Bev/C. Both elastic and inelastic scatterings were accepted. The number of muons incident on the carbon target was 10,795,728. A total of 784 muon scatters were observed. The number and angular distribution was compared with the yield calculated. One of the contributions to the scattering cross section in this analysis arises from spatial correlations of particles in the nucleus. Estimates of this contribution based on four different theories of nuclear matter were used in the Drell-Schwartz analysis to calculate scattering yields. The calculated yields were compared with the yield measured. The results of this experiment do not indicate a choice between the j-j shell model estimate, the estimate of the shell model with a hard core nuclear force, or even the no correlation estimate of the internucleon correlation term. It is clear, however, that the Bohr-Mottelson shell model estimate of this term overestimates the internucleon correlation contribution. The accuracy of the measurement and the comparison are discussed. (Dissertation Abstr., 24: No. 11, 1964)

**28740** WEAK INTERACTION EFFECTS IN ELECTRODYNAMICS. Richard Alan Carhart. Thesis. Madison, Wis., Univ. of Wisconsin, 1964. 104p.

The problem of how the electromagnetic interaction of various particles is modified by the strangeness-conserving weak interactions was examined in several ways. Possible types of modification are given for the electron, muon, neutrinos, nucleons, and pions, with a summary of quantitative results as presently known. The main part of the electromagnetic interaction of all the leptons is given by quantum electrodynamics, which is taken as the basis for further discussion. A general parity non-conserving interaction is then added to the Lagrangian. Renormalization of the extended theory is treated independent of perturbation theory; and results agreeing with previous investigations were obtained. In addition, it is proven that the renormalized vertex contains no constant $\gamma_\alpha\gamma_5$-term, or pseudo-charge, if the bare electromagnetic vertex does not. Next, the discussion is specialized to the electron and the corrections of order $\alpha G$ to its interaction with an external electromagnetic field, where $G = 10^{-5}\ M_p^{-2}$. These corrections are calculated in perturbation theory with a cutoff, assuming an intermediate vector meson theory of weak interactions. Finally, parity non-conserving effects in atoms and molecules are discussed, based on the perturbation calculation. The $2\ ^2P^1/_2$ admixture to the $2\ ^2S^1/_2$ state of hydrogen was found to be in the range $10^{-13}$ to $10^{-11}$ for reasonable values of parameters. Also, a theoretical upper limit of $10^{-18}$ on the parity impurity of the ground state of $O_2$ is suggested, well below the experimental upper limit of $3 \times 10^{-8}$. Factors that should be considered in selecting a more favorable experiment are mentioned. A discussion of limitations of the present approach to the question of corrections is included. (Dissertation Abstr., 24: No. 11, 1964)

**28741** THE EFFECT OF NUCLEAR STRUCTURE ON RADIATIVE CORRECTIONS TO BETA DECAY. Bernard Chern. Thesis, Raleigh, N. C., Univ. of North Carolina, 1962. 123p.

The effect of nuclear structure on the radiative correction to beta decay corresponding to the exchange of a virtual photon between the nucleus and the beta ray was calculated. The results are divided into two parts. One part contains those terms in which the same nucleon takes part in both the beta decay and the electromagnetic interactions. This is shown to be in formal agreement with the results quoted by others, but the analysis suggests that the radiative corrections change the half life of $^{14}O$ by only −0.9%. The second part contains the terms in which two different nucleons take part in the two interactions, and represents the effect of nuclear structure on the radiative correction to beta decay. The two-nucleon terms were evaluated for the case of allowed beta decay and were found to be $\approx \alpha/10$ times the first order beta decay. The calculation does not close the gap between the coupling constants for muon and beta decay assuming a Universal Fermi Interaction. The shape of the allowed energy spectrum is not affected by the two-nucleon terms to zeroth order in px. The extension of the calculation to forbidden decays is discussed. (Dissertation Abstr., 24: No. 11, 1964)

**28742** THE SELF-COUPLING OF THE NEUTRINO ELECTRON CURRENT AND NEUTRINO INDUCED REACTIONS. Binayak Dutta-Roy. Thesis, Princeton, N. J., Princeton Univ., 1963. 75p.

The cross section for the pair production by a neutrino in the coulomb field of a nucleus is calculated. The Weizsacker-Williams method is analysed. (Dissertation Abstr., 24: No. 11, 1964)

**28743** AN INVESTIGATION OF THE RADIOACTIVE ISOTOPES PRODUCED BY $He^3$ BOMBARDMENT OF $Sm^{147}$ AND $Gd^{152}$. Raymond Hal Kelley. Thesis, Columbus, Ohio, Ohio State Univ., 1963. 63p.

Oxides of gadolinium (enriched 36.2% in $^{152}Gd$) and samarium (enriched 97.8% in $^{147}Sm$) were bombarded with 15 Mev $^3He$ nuclei. Attempts were made to identify the radionuclides produced and their decay schemes, to compare the experimental data and the conclusions drawn therefrom with previously reported investigations, and to calculate the relative cross sections for the $^3He$ induced reactions. Multi-channel analyzers were used on conjunction with NaI(Tl) scintillation detectors to measure the energies, half lives, coincidences, and intensities of the gamma rays emitted by the radioactive isotopes. The alpha particle activities were measured with a solid state charged particle detector. At 15 Mev at least six reaction channels have a probability of occurrence: ($^3He$,T), ($^3He$,d), ($^3He$,p), ($^3He$,n), ($^3He$,2n), and ($^3He$,3n). The low enrichment of $^{152}Gd$ precluded calculation of the relative cross sections for these reactions, but the decay systematics of the radionuclides produced were in good agreement with those reported. In the case of highly enriched samarium samples, it was possible to identify not only the radionuclides produced from the $^{147}Sm$ + $^3He$ reaction but the relative amounts of each produced as well. The $^{147}Sm$ + $^3He$ reactions ($^3He$,T), ($^3He$,d), ($^3He$,p), ($^3He$,n), ($^3He$,3n) were, respectively, in the ratios (12 ± 6) : (10.2 ± 3.9) : (22 ± 11) : (5.8 ± 1.2) : (10.9 ± 1.6). (Dissertation Abstr., 24: No. 11, 1964)

**28744** DEUTERON INDUCED REACTIONS OF OXYGEN 16. Hyun Chang Kim. Thesis, Columbus, Ohio, Ohio State Univ., 1963. 74p.

Absolute differential cross sections were measured for the reactions of $^{16}O(d,\alpha_0)^{14}N$, $^{16}O(d,p_0)^{17}O$, and $^{16}O(d,p_1)^{17*}O$ for deuteron energies from 0.80 to 1.7 Mev at laboratory angles of 164°15′, 142°11′, 127°40′, 86°40′, 66°56′, and 51°24′. The measurements were made with a differentially

pumped gas scattering chamber and solid state surface barrier counter. Analysis of the experimental data was based upon the assumption of compound nucleus formation alone for the region around 1 Mev. The compound nucleus calculations, under quite restrictive assumptions, demonstrate that it is possible to explain the data for $^{16}O(d,\alpha_0)^{14}N$ angular distributions by assuming resonant contributions from two levels having different parities, but it is apparently not possible to explain the results for the $^{16}O(d,p_1)^{17}O$ and $^{16}O(d,p_1)^{17*}O$ reactions with compound nucleus theory alone. Parameters for two states in the compound nucleus $^{18}F$, which are important, are summarized. (Dissertation Abstr., 24: No. 11, 1964)

**28745** STATISTICAL THEORY OF ENERGY-LEVEL SPACING DISTRIBUTIONS FOR COMPLEX SPECTRA. Harvey Sherwin Leff. Thesis, Iowa City, Iowa State Univ., 1963. 192p.

Attempts were made to give precise mathematical definitions for the mth order spacing distributions without specifying a particular ensemble, to obtain a connection between ensembles of Hermitian matrices and ensembles of unitary matrices, to introduce an entire class of generalized ensembles for which various statistical properties can be calculated formally, and to use the formalism of the first to find the mth order distributions for series of levels with mixed spins and parities. Two formalisms were obtained to calculate the mth order spacing distributions. One is used to treat random, statistically independent levels, yielding the Poisson distributions. The other reduces to a procedure already used for m = 0,1; no completely satisfactory derivation appears in the literature. Assuming Dyson's unitary matrices to be some function of the Hamiltonian, a connection was obtained between Dyson ensembles and a large class of Hamiltonian matrix ensembles. It is conjectured that many of these so-called generalized ensembles yield the same spacing distributions. The normalization constant, level density, and nearest neighbor spacing distribution were formally calculated for arbitrary unitary-generalized ensembles. A unique set of orthogonal polynomials is associated with each generalized ensemble. The results are in terms of these. A Legendre ensemble is introduced that has the same nearest neighbor distribution as the Dyson and Wigner (Gaussian) ensembles, but a very different level density (concave upward). A general formalism for treating mixed sequences was obtained assuming levels of different sequences to be statistically independent. For n sequences the mth order distributions and their first derivatives are evaluated at x = 0. For an infinite number of sequences the distributions were found to be the Poisson distributions. The nearest and next-nearest distributions were numerically calculated for various values of the level density ratio. Finally, the correlation coefficients between adjacent groupings of spacings are defined; these are calculated for several special cases. (Dissertation Abstr., 24: No. 11, 1964)

**28746** ALPHA-INDUCED NUCLEAR REACTIONS ON MOLYBDENUM: ANGULAR MOMENTUM EFFECTS ON COMPOUND NUCLEUS DECAY. Robert Alan Esterlund. Thesis, St. Louis, Washington Univ., 1963. 141p.

Absolute excitation functions for the following reactions were measured: $^{92}Mo(\alpha,n)^{95}Ru$; $^{92}Mo(\alpha,p)^{95g}Tc$; $^{92}Mo(\alpha,p)^{95m}Tc$; $^{92}Mo(\alpha,\alpha'n)^{91g}Mo$; $^{92}Mo(\alpha,\alpha'2n)^{90}Mo$; $^{92}Mo(\alpha,\alpha'pn)^{90g}Nb$; $^{92}Mo(\alpha,p3n)^{92}Tc$; $^{92}Mo(\alpha,pn)^{94m}Tc$; $^{94}Mo(\alpha,p2n)^{95m}Tc$; $^{100}Mo(\alpha,n)^{103}Ru$ + $^{100}Mo(\alpha,p)^{103}Tc$; $^{100}Mo(\alpha,\alpha'n)^{99}Mo$ + $^{100}Mo(\alpha,\alpha'p)^{99}Nb$. In addition, relative excitation functions for the reactions $^{92}Mo(\alpha,2n)^{94}Ru$ + $^{92}Mo(\alpha,pn)^{94g}Tc$, and $^{92}Mo(\alpha,3n)^{93}Ru$ + $^{92}Mo(\alpha,p2n)^{93m}Tc$ + $^{92}Mo(\alpha,p2n)^{93g}Tc$ were measured. The data from the reactions involving single particle emission from the compound nucleus were analyzed via the statistical model (following previous published practice with neglect of nuclear angular momentum effects); the values of a, the level density parameter, which have been found to lead to agreement of the calculated cross-sections with those from the data are far smaller (<A/20) than the values predicted by the Fermi gas model (a = A/8 to A/10). Additional calculations were performed in an attempt to take into account the distribution of angular momentum induced in the compound nucleus by the bombarding projectile, and the effect this distribution will have on compound nucleus decay. In general, particle emission from states of high angular momentum will only occur readily to energy regions in the residual nucleus where states of comparable angular momentum exist. The values of a derived from comparison of the results of these calculations with the experimental data agree with those values predicted by the Fermi gas model the derived values of I/Ir, the ratio of the nuclear moment of inertia to the moment of inertia of a rigid spherical body of the same mass and radius as the nucleus, agree reasonably well with I/Ir values derived from previous analysis of isomer yield ratios from other nuclear reaction studies. This would seem to indicate that the neglect of angular momentum effects has been the cause of the anomalously low a-values previously observed. (Dissertation Abstr., 24: No. 11, 1964)

**28747** SEARCH FOR AN ANOMALY IN THE RADII OF THE LEAD ISOTOPES. Gregory Mendel Haas. Thesis, Baton Rouge, Louisiana State Univ., 1963. 129p.

A report is made on measurements of the nonelastic cross sections of lead-206 and lead-208 for 14 Mev neutrons using the sphere transmission technique. The measurements were performed in order to test the validity of the results of the calculations on the radii of these isotopes from the one-body theory of alpha decay. From the systematics of alpha decay it was found that a large difference in half life occurs between the two isotopes of polonium, Po-210 and Po-212. Calculations of the daughter radii (Pb-206 and Pb-208) from the one-body theory of alpha decay predict a difference in radii of about eight (8) per cent or a difference in cross section of about eighteen (18) per cent. The nonelastic cross section measurements were made on ordinary lead (Pb-204, 1.4%; Pb-206, 25.2%; Pb-207, 21.7%; Pb-208, 51.7%) and radiolead (Pb-204, 0.08%; Pb-206, 88.25%; Pb-207, 8.78%; Pb-208, 2.92%). The nonelastic cross sections measured for the ordinary lead and radiolead are, respectively, 2.53 ± 0.05 and 2.50 ± 0.04 barns. From these results the cross sections of lead-206 and -208 were computed and yielded a cross section difference of 3.2 ± 4.0%. (Dissertation Abstr., 24: No. 11, 1964).

**28748** THE DECAY OF $Cs^{136}$. Richard Frederick Reising. Thesis, St. Louis, Washington Univ., 1963. 148p.

Scintillation spectrometry and high-resolution electron magnetic spectrometry were applied in the study of 12.9-day $^{136}Cs$. The decay of this nuclide was observed to be associated with gamma transitions of the following energies (and intensities in parentheses): 67 kev(15.3), 86 kev (5.8), 153 kev(7.5), 164 kev(17.7), 176 kev(16.2), 273 kev (13.6), 340 kev(49.1), 818 kev(100.0), 1053 kev(79.2), and 1240 kev(18.6). Data from gamma-gamma coincidence scintillation spectra, single-crystal and two-crystal sum-spectra, Hoogenboom spectra, and K-conversion coefficients and K-to-L conversion coefficient ratios were interpreted in terms of energy levels of $^{136}Ba$ with the following

spin and parity values (and energies above the ground state in parentheses), 0+(0 kev), 2+(818 kev), 4+(1871 kev), 7−(2035 kev), 4+(2058 kev), 5−(2144 kev), and 6+(2211 kev). Kurie analysis of the electron continua from the magnetic spectrometry studies and from beta-gamma-gamma coincidence scintillation spectrometry studies yielded beta-ray groups with the following energies (and relative intensities in parentheses): 342 kev(91.5), [409 kev(0.1)?], 495 kev(1.9), and 682 kev(6.5). These groups populate the levels of $^{138}$Ba at 2211, 2144, 2058, and 1871 kev, respectively. Evidence is presented for the existence of an isomer of $^{138}$Ba identified as the 2035-kev excited state, which is believed to be the 0.32-second activity observed by others among the products of a $^{137}$Ba(n,γ)$^{138}$Ba reaction. Log(ft) values calculated for the above beta groups are consistent with a 5+ assignment to the ground state of $^{138}$Cs. The nucleon configurations are discussed in terms of shell-model theory. (Dissertation Abstr., 24, No. 11, 1964)

**28749** ANALYSIS OF THE HYPERTRITON IN TERMS OF HARD-CORE POTENTIALS. Donald Roy Smith. Thesis, Boulder, Colo., Univ. of Colorado, 1963. 94p.

An upper bound was set on the strength of the average Λ-nucleon potential effective in the hypertriton ($_{\Lambda}H^3$) for assumed hard-core radii of 0.2, 0.4, and 0.6 F by utilizing the variation method to establish the potential strength required to reproduce the observed binding energy of that system. Only two-body central Λ-nucleon potentials were considered with a trial wave function that represented each pair of particles in a relative S-state. Trial wave functions containing four and ten variation parameters were used. Although the ten-parameter wave function gave better results, the improvement in the value of the strength of the interaction was less than six percent over that obtained with the four-parameter trial wave function. This suggests that reasonably reliable results can be obtained in subsequent studies with a four-parameter wave function. The structure of the Λ-nucleon potential was observed to be insensitive to the nucleon-nucleon potential so long as the latter is consistent with the binding energy of the deuteron. Further, the well-depth parameter of the required potential was observed to increase as the assumed hard-core radius was increased; however, only the largest of the hard-core radii considered here implied that a bound state exists for the hyperdeuteron ($_{\Lambda}H^2$). Since the hyperdeuteron has never been observed, this may suggest that the radius of the hard core in the Λ-nucleon interaction is less than 0.6 F. Results of the calculations were compared with the results of previous studies of the Λ-nucleon potential parameters. In addition, the values of the interaction strength were used to obtain the well-depth and low energy S-wave scattering parameters of the effective Λ-nucleon potential. The values for the scattering lengths were found to be in the range between −1.8 to −2.1 F for potentials having hard-core radii 0.2 F to 0.6 F, indicating that a scattering length of −2 F may provide an approximate characterization of the average interaction for any hard core radius in this range. (Dissertation Abstr., 24: No. 11, 1964)

**28750** COULOMB AND DIFFRACTION DISSOCIATION OF 16.2 Bev/c NEGATIVE PIONS. P. L. Jain, J. D. Rinaldo, and P. D. Bharadwaj. 4p. (CONF-481-63)

From American Physical Society Annual Meeting, New York, Jan. 1964.

Nuclear emulsions exposed to a meson($\pi^-$) beam at 16.2 Bev/c were examined. Multiple meson($\pi$) production events are discussed. Coulomb and diffraction dissociation are considered as mechanisms for these events. (C.E.S.)

**28751** ELASTIC SCATTERING OF α PARTICLES BY $Be^9$. R. B. Taylor, N. R. Fletcher, and R. H. Davis (Florida State Univ., Tallahassee). 7p. (CONF-481-59)

From American Physical Society Annual Meeting, New York, Jan. 1964.

Cross sections for the elastic scattering of alpha particles by beryllium-9 were obtained for energies from 6 to 20 Mev in order to investigate the existence and formation of alpha clusters inside the nucleus. Excitation curves and angular distributions are illustrated. (C.E.S.)

**28752** ISOBARIC SPIN ANALOGUE STATES. J. D. Fox (Florida State Univ., Tallahassee). 17p. (CONF-396-5)

From Symposium on Nuclear Spectroscopy with Direct Reactions, Argonne, Ill., Mar. 1964.

Isobaric analogue states in heavy nuclei were observed as compound nucleus resonances excited in (p,n) and (p,p) reactions. Experiments in the Zr-Mo region gave exceptional agreement with results of (d,p) nuclear spectroscopy. The experiments, resonance analysis, and capabilities of the resonance measurements for nuclear spectroscopy are discussed. (D.C.W.)

## Plasma Physics and Thermonuclear Processes

**28753** (AD-411584) ELECTRON ENERGY DISTRIBUTION IN A PHOTOELECTRIC EXCITED CESIUM PLASMA (thesis). Richard Paul Firsdon (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio). June 1963. 69p. (GE/EE/62-6)

A theoretical analysis of the electron energy distribution of a photoelectric excited cesium vapor is discussed. The steady-state solution of the differential equation involving generation, ambipolar diffusion, and a constant recombination term is presented. The differential equation is developed. An experimental design for measuring the electron energy distribution while independently varying the frequency and intensity of radiation, temperature and pressure of the cesium vapor, and distance from the source of ionization is analyzed. (auth)

**28754** (AD-415622) PLASMA DIAGNOSTICS STUDIES FOR CROSSED-FIELD ACCELERATORS. Andrew Proudian (Electro-Optical Systems, Inc., Pasadena, Calif.). Mar. 1963. Contract AF49(638)-1063. 30p. (RN-11)

Diagnostic methods investigated include: spectroscopic and interferometric methods; optical inteferometry, continuum intensity, line shape (series limit), and relative and absolute line intensity measurements; measurements involving the use of particle beams; electron scattering, charge exchanger, and excitation of target gas. (auth)

**28755** (AD-418411) ELECTRON-ION AND ION-ION RECOMBINATION. Technical Report No. 2. Manfred A. Biondi (Pittsburgh. Univ.). Sept. 19, 1963. Contract Nonr 624(06). 46p. (APP-4)

Information obtained from laboratory experiments and theoretical calculations concerning electron-ion and ion-ion recombination processes is reviewed. It is concluded that the two-body processes of dissociative recombination and radiative recombination between electrons and positive ions and of mutual neutralization of positive and negative ions are of importance for the ionosphere. Laboratory afterglow measurements on ions of ionospheric

interest yield values for the dissociative recombination coefficients. Theoretical calculations yield radiative recombination values for H(+), He(+), O(+) ions, and electrons of 4 to $5 \times 10^{-12}$ cc/sec at 250°K and a $T_e^{0.5}$ dependence on electron temperature. Auxiliary processes affecting ionospheric recombination, such as electron attachment to $O_2$ molecules, charge transfer both for positive ions and negative ions, and ion conversion, are briefly considered. (auth)

**28756** (AEDC-TDR-64-22) PARTITION FUNCTIONS AND THERMODYNAMIC PROPERTIES OF HIGH-TEMPERATURE GASES. Kenneth S. Drellishak (Northwestern Univ., Evanston, Ill. Gas Dynamics Lab.). Jan. 1964. Contract AF40(600)-972. 157p. (AD-428210)

Assuming a mixture of perfect gases consisting of atoms, molecules (neutral and singly ionized), negative atomic ions, electrons, and up to four positive atomic ions, the equilibrium composition, internal partition functions, and thermodynamic properties of argon, nitrogen, and oxygen plasma were calculated by the methods of statistical mechanics for six pressures (0.01, 0.1, 0.5, 1.0, 2.0, and 5.0 atmospheres) at 100°K increments for temperatures up to 35000°K. Tables and figures include internal partition functions for all heavy species, chemical composition, mass density, entropy, internal energy, enthalpy, Gibb's and Helmholtz free energies, specific heats at constant pressure and volume, the effective gamma, and equilibrium sound speed. The internal partition functions for nitrogen molecular species were calculated by an approximate technique proposed by Mayer and Mayer using the most recent spectroscopic data available. For oxygen molecular species, the method of Stupochenko et al., was employed to determine the intermolecular potential curves and the internal partition function was computed by direct summation over the energy states so determined. The electronic partition functions for atoms and atomic ions were computed using published data for observed electronic energy levels plus estimated energies for electronic states which are predicted but not spectroscopically observed. These electronic partition function series were terminated by application of the Debye cutoff criterion and a corresponding lowering of the ionization potential was included. An outline of the procedure followed in the calculations is presented and the two methods of computing the molecular internal partition function are compared and evaluated. The effect of the Debye cutoff criterion and lowering of the ionization potential are discussed. Presented are a table of Jacobian transformation constants which were used to obtain certain cross derivatives in the calculation of specific heat at constant volume and acoustic velocity; summary curves of all thermodynamic properties computed; and flow diagrams for computer programs used in the calculations. (auth)

**28757** (AFOSR-5119) CONDUCTION THEORIES IN GASEOUS PLASMAS AND SOLIDS. Final Report, November 1, 1961–December 31, 1962. (New Hampshire. Univ., Durham). Mar. 1963. 31p. (AD-414401)

The studies were concerned with improving the correlation between theoretical prediction and experimental observation of the transport properties of ionized media. The microwave diagnostic techniques were extended and brought to final completion. With this formulation it is possible to examine in some detail the properties of an anisotropic dielectric or plasma in a geometry which minimizes the effect of boundaries. In addition, an attempt was made to ascertain the effect of a modified collision model on the electromagnetic properties of a partially ionized plasma in the presence of a d-c magnetic field. The results, while of some theoretical interest, are of negligible practical importance—except possibly in the magnetohydrodynamic limit. The primary efforts concerned (a) Interaction between electromagnetic waves and cold plasmas, and (b) Conductivity theory of partially ionized plasmas. (auth)

**28758** (ATN-64(9231)-3) SOME OBSERVATIONS OF PLASMA TURBULENCE. R. Betchov, R. C. Phillips, and E. B. Turner (Aerospace Corp., El Segundo, Calif.). Apr. 24, 1964. 22p.

The random fluctuations of the magnetic field during a linear pinch were observed in detail. Under given conditions, the fluctuations are statistically reproducible. However, the fluctuations have a complicated geometry, and certain asymmetries remain unexplained. It appears that the current sheath is preceded by a shock wave as seen in a space time-chart description. Magnetic fluctuations were observed from 1 to 50 Mc, which is the cutoff frequency of the probes. Examples of correlation are given as well as double probe signals obtained with two coils in a single quartz tube. It was observed that, after a long rest, the first discharge did not show turbulence. This points out the importance of the wall conditions. (auth)

**28759** (CONF-433-4) SOME MATERIALS PROBLEMS IN THE CONSTRUCTION OF A FUSION POWER REACTOR. J. F. Potts, Jr. (Oak Ridge National Lab., Tenn.). [1967]. Contract W-7405-eng-26. 34p.

From American Society Testing Materials 1964 International Conference on Materials, Philadelphia, Feb. 1964.

Some problems in materials selection for controlled thermonuclear fusion reactors are discussed. The state-of-the-art in fusion research is reviewed. (R.E.U.)

**28760** (LRP-13-64) OSCILLATEUR HF DE 8 MW POUR LA PHYSIQUE DES PLASMAS. (8-Mw h-f Oscillator for Plasma Physics). A. Lietti and M. Geiger (Laboratorie de Recherches sur la Physique des Plasmas, Lausanne, Switzerland). Apr. 1964. 20p.

A 4-tube 8-Mw push-pull oscillator is described. It operates at 5 to 10 Mc, delivering a 2-by-30 kv peak, 22.6 kamp and 680 Mva. Standard RS 1041 tubes and a mainly air-coaxial type of circuit with concentrated capacitors are used. The pulsed power supply was realized using triggered spark gaps. A certain automaticity is provided for the timing system, switching, and interlock. A triggered electronic crowbar protects the tubes against internal arc discharges. The technical possibility of realizing a super-power oscillator with a great number of tubes is discussed. Models with 10 to 20 tubes were constructed. (auth)

**28761** (MATT-252) NUMERICAL COMPUTATIONS FOR ION PROBE CHARACTERISTICS IN A COLLISIONLESS PLASMA. Francis F. Chen (Princeton Univ., N. J. Plasma Physics Lab.). Feb. 1964. Contract AT(30-1)-1238. 58p.

Numerical results in ranges of experimental interest are presented in graphical form for the potential profile around negatively biased spherical and cylindrical probes in a collisionless plasma and for the saturation ion current-voltage characteristics. The computations were made on the basis of the theories of Allen, Boyd, and Reynolds for zero ion temperature and of Bernstein and Rabinowitz for monoenergetic ions. Curves necessary for the use of Lam's theory, which is applicable for large probes, are also included. (auth)

**28762** (RADC-TDR-63-465(Vol.1)) INVESTIGATION OF NEW CONCEPTS FOR MICROWAVE POWER GENERATION (PLASMA STUDIES). Final Report. (Cornell Univ., Ithaca, N. Y. School of Electrical Engineering). Dec. 1963. Contract AF30(602)-2833. 226p. (AD-427003)

Separate abstracts were prepared for 4 sections; test vehicle for electron beam-plasma interactions, analysis of electron beam-plasma interactions, plasma diagnostics, and ion-induced oscillations of electron beams. (R.E.U.)

*For abstracts of individual papers see: 28763, 28764, 28765, and 28766.*

**28763** (RADC-TDR-63-465(Vol.1)(Paper 1)) A TEST VEHICLE FOR THE STUDY OF THE INTERACTION OF A HIGH-POWER ELECTRON BEAM WITH A PLASMA. L. F. Eastman, D. Kerr, H. Marantz, Y. Narayan, and J. J. Clark (Cornell Univ., Ithaca, N. Y. School of Electrical Engineering). 53p.

The design and construction, and preliminary experimental results, of a test vehicle for studying plasma-electron beam interaction are described. Two connected chambers of the test vehicle, one at hydrogen pressures as high as 1/1000 torr for generation of plasma and the other at pressures less than 1/100,000 torr for the generation of a high-power electron beam in a convergent flow gun, are described. A demountable subassembly for generating the plasma and directly coupling S-band signals to and from the plasma and the electron beam by means of a cavity is described. The use of the cavities to diagnose the plasma is described in part. The electron gun used to generate the 5-kv unity microperveance beam, having 0.20 in. diam. in semiconfined flow, is described. This beam is passed from the low-pressure gun chamber into the high-pressure plasma chamber. A beam scanner for studying the properties of the electron beam in the gas and plasma environment is also described. (auth)

**28764** (RADC-TDR-63-465(Vol.1)(Paper 2)) ANALYSIS OF THE INTERACTION OF AN ELECTRON BEAM WITH A PLASMA. H. Marantz (Cornell Univ., Ithaca, N. Y. School of Electrical Engineering). 57p.

A detailed analysis is made of the gain characteristic of the beam-plasma amplifier. The first section is a study of the general specification of a plasma and of the d-c plasma discharge in particular. It is found that the analysis of the low-pressure Penning discharge must take particle streaming under consideration to account for the discharge current and the percentage of ionization. Several mechanisms for broadening the gain characteristic of an infinite beam plasma are analyzed. It is concluded that the beam-plasma inhomogeneities account for the greatest change in the gain characteristic. Corrections for plasma collisions and temperature can be neglected for the experimental values expected. (auth)

**28765** (RADC-TDR-63-465(Vol.1)(Paper 3)) PLASMA DIAGNOSTICS. D. M. Kerr (Cornell Univ., Ithaca, N. Y. School of Electrical Engineering). 43p.

The design and use of singly re-entrant cavities in an electron-beam hydrogen-plasma system are described. The cavities serve as the input and output coupling structures of a beam-plasma amplifier and, in addition, they are used to investigate the properties of the plasma discharge. Perturbation of a resonant cavity by a plasma is discussed and equations are obtained relating the shifts in resonant frequency and cavity Q to the average electron density and collision frequency. Some typical experimental results are given and a linear relation is found between resonant frequency shift and discharge current. (auth)

**28766** (RADC-TDR-63-465(Vol.1)(Paper 4)) ION-INDUCED OSCILLATIONS OF ELECTRON BEAMS. A. S. Gilmour, Jr. (Cornell Univ., Ithaca, N. Y. School of Electrical Engineering). 43p.

The results of measurements of the properties of transverse and radial ion-induced electron-beam oscillations are described in detail. From the data on the transverse oscillations and from data published, it is concluded that the transverse oscillations increase in amplitude with time because of interaction after the electrons enter the magnetic focusing field. Because the ion core disturbs the potential well caused by the electrons, the electron beam follows a helical path from the gun to the collector. Ions or electrons traveling toward the gun alter the helical path and cause the oscillations to grow. The radial oscillations were found to occur at a frequency that was 1.4 to 2 times the transverse frequency. They increase in amplitude with time because, accompanying the oscillation of the ion core, there is a density modulation of the ions in the core that affects the focusing of the electron beam in the convergent Pierce gun in a periodic manner. This causes the diameter of the electron beam to oscillate, which in turn causes the radial oscillations of the ions to grow. Suggestions are made for the control or elimination of radial and transverse oscillations. (auth)

**28767** (RADC-TDR-63-477) MILLIMETER WAVE COMPONENT DEVELOPMENT (BEAM-PLASMA AMPLIFIER). Paul Chorney (Microwave Associates, Inc., Burlington, Mass.). Dec. 1963. Contract AF30(602)-2948. 22p. (AD-427059)

Probe measurements are described that show that the plasma column of the PIG discharge has a nonuniform axial density profile. Experiments are also described in which plasma densities of $3 \times 10^{14}$ cm$^{-3}$ are measured with a discharge current of 1 amp in xenon gas at 98 mtorr. Other measurements obtained from this tube are in disagreement with the previous tube. The theory of electron beam scattering is examined and it is found that electron-atom collisions have a larger effect than electron-ion collisions. Mean-free-paths of several centimeters are predicted for beam electrons in a beam-plasma system having 50% ionization and a plasma density of $10^{15}$ cm$^{-3}$. Results obtained in the plasma tester need re-examination because of the disagreement with the earlier plasma tester. From the theoretical studies it is concluded that highly ionized plasmas are desirable for amplifier applications because of the longer mean-free-paths that exist. Recommendations are made and plans for the forth-coming quarter are outlined. (auth)

**28768** (SIT-122) RADIATIVE MODES OF A MAGNETOPLASMA SLAB. Special Report. G. Halpern and G. Schmidt (Stevens Inst. of Tech., Hoboken, N. J.). May 1964. Contract AT(30-1)-2813. 60p.

It is shown that there exist modes of oscillation of a cold magnetoplasma slab that generate outgoing electromagnetic radiation. The dispersion relation, which relates the frequency and wave-number of these modes, is derived. An analysis of this equation is made with emphasis on waves having phase velocity greater than light in vacuum. These waves are found to have complex frequencies due to radiation damping. For long wavelengths the radiation frequencies are near $\omega_p$ and $(\omega_p^2 + \omega_c^2/4)^{\frac{1}{2}} \pm \omega_c/2$; where $\omega_p$ and $\omega_c$ are the electron plasma and cyclotron frequencies, respectively. Dispersion curves are drawn for arbitrary values of applied magnetic field. The behavior of these curves is discussed in the transition to an un-

bounded plasma. Temperature, ion dynamics, and collisions are neglected in the analysis. (auth)

**28769** (TID-20644) STUDIES OF PLASMA OSCILLATIONS. Quarterly Status Report No. 17, December 1, 1963–February 29, 1964. (Stanford Univ., Calif. Microwave Lab.). May 1964. Contract AT(04-3)-326. 18p. (ML-1161)

Experimental and theoretical studies are reported of the interactions of plasma with electron beams; ion waves in plasma; and double plasma sheaths at tube constrictions. (T.F.H.)

**28770** (TID-20709) THERMONUCLEAR PLASMA STUDIES. Quarterly Status Report No. 5. (Wisconsin. Univ., Madison). Apr. 30, 1964. Contract AT(11-1)-1233. 15p.

The behavior of plasma in the toroidal octupole was studied. The transient fields at the injection port were studied at the time of plasma injection. Radio-frequency determination of plasma density was carried out and compared with Langmuir probe results. (R.E.U.)

**28771** (UCRL-7712) FEASIBILITY CONSIDERATIONS IN THE APPLICATION OF LASER DIAGNOSTICS TO PLASMAS OF DENSITY ~$10^{13}$ $cm^{-3}$. Robert E. Ellis and Frederick R. Kovar (California. Univ., Livermore. Lawrence Radiation Lab.). Mar. 16, 1964. Contract W-7405-eng-48. 29p.

The feasibility of the use of a pulsed ruby laser system for determining plasma electron temperature and density is examined, assuming an electron density of ~$10^{13}$ $cm^{-3}$ and an electron temperature of ~100 ev. The signal, to be obtained by detecting a portion of the Doppler-broadened spectral distribution of laser radiation scattered at 90° to the incident beam, is calculated. Effects of plasma bremsstrahlung, stray light from the primary laser beam, and light from excited, partially ionized atoms are estimated. It is pointed out that in principle, the unpolarized light from the plasma may be discriminated against by splitting the light entering the viewing system into two mutually perpendicular, polarized components, which are then to be detected separately and nulled out in a differential amplifier. A brief consideration of the use of laser interferometry for the determination of plasma electron density is included. It is concluded that the measurement of plasma electron density and temperature may be accomplished with a pulsed laser output of ~$10^{8}$ w provided sufficient care is taken to eliminate the effects of laser stray light and plasma light. It also appears that under the conditions contemplated, the laser beam will not significantly perturb the plasma. (auth)

**28772** NONLINEAR GROWTH OF THIRD HARMONIC OF AN ELECTROMAGNETIC WAVE IN A PLASMA. Mahendra Singh Sodha and Carl James Palumbo (Republic Aviation Corp., Farmingdale, N. J.). Can. J. Phys., 42: 1236-41(June 1964).

Using the recent results of Rosen, an expression was obtained for the nonlinear current density in a slightly ionized plasma due to an electric field $E = E_1 \exp(i\omega t) + E_3 \exp(3i\omega t)$. This expression was substituted in the wave equation, and the resulting nonlinear differential equations were solved by the method of successive approximations to obtain an explicit expression for the growth of the third harmonic of an electromagnetic wave in a plasma. (auth)

**28773** ON SPECTRAL LINE BROADENING IN THE PLASMA. S. L. Mandelstam and M. A. Mazing (Lebedev Inst. of Physics, Moscow). Colloq. Spectros. Intern. 8th, Lucerne, Switz., 1959, 184-7(1960).

The width and shift of spectral lines with quadratic Stark effect were investigated experimentally in the plasma of a spark discharge in an atmosphere of argon and helium. Experimental results differed radically from the Weisskopf-Lindholm theory. On the other hand, good agreement was obtained with the time-dependent theory developed by Sobelman and Vainstein. It is shown that it is preferable to use the line-shift and not the line-width for determination of electron concentration. (auth)

**28774** PLASMA DIAGNOSTICS BASED ON REFRACTIVITY. U. Ascoli-Bartoli. Comit. Nazl. Energia Nucl., Notiziario, 10: No. 4, 27-33(Apr. 1964). (In Italian)

Plasma is described as a medium possessing its own refractivity. A review is made of the information that may be obtained by taking advantage of these properties. The interferential, strioscopic, and shadow methods for measuring the refractivity are described. (J.S.R.)

**28775** EQUATIONS FOR EVOLUTION OF THE ONE-PARTICLE DISTRIBUTION FUNCTION OF A STABLE OR SLIGHTLY UNSTABLE PLASMA. Guy Laval and René Pellat. Compt. Rend., 258: 3997-4000(Apr. 20, 1964). (In French)

Simplified equations for the evolution of the particle distribution function are obtained for the case of a homogeneous electron plasma with no magnetic field. (D.C.W.)

**28776** THE TOPOGRAPHY OF THE MAGNETIC FIELD IN AN ANNULAR DUOPLASMATRON. ITS INFLUENCE ON THE FIXATION OF THE DISCHARGE. Rudolf Becherer, André Bariaud, and Francois Prévot (EURATOM-CEA, Fontenay-aux-Roses, France). Compt. Rend., 258: 4450-3(May 4, 1964). (In French)

A discharge of the duoplasmatron type was realized using a ring with a mean diameter of 25 cm. The existence and position of the discharge depend on the form of the magnetic field between the intermediate electrode and the anode. (tr-auth)

**28777** PROGRESSIVE-WAVE PLASMA ACCELERATORS. THEORETICAL STUDY. René Bardet, Térenzio Consoli, Richard Geller, Francois Parlange, and Micheline Weill. Compt. Rend., 258: 4454-7(May 4, 1964). (In French)

The motion of ions and electrons in the electromagnetic field of waves with right circular polarization near the electron cyclotron resonance was calculated for the case of a static magnetic field gradient associated with the waves. (D.C.W.)

**28778** CONDITIONS FOR UNIFORMITY OF THE DISCHARGE OF AN ANNULAR DUOPLASMATRON. Rudolf Becherer, André Bariaud, and Francois Prévot (EURATOM-CEA, Fontenay-aux-Roses, France). Compt. Rend., 258: 4674-7(May 11, 1964). (In French)

The uniformity of the discharge of an annular duoplasmatron was found to depend strongly on its magnetic field. The ion current and energy near the anode increase with the magnetic field. A good electrode geometry is an equally necessary condition. (D.C.W.)

**28779** COAXIAL GUN. Paul-Étienee Fraugeras, Jacques Lasry, and Didier Véron (EURATOM-CEA, Fontenay-aux-Roses, France). Compt. Rend., 258: 4678-81(May 11, 1964). (In French)

A plasma gun with coaxial electrodes and annular preionization is described. Measurements on the plasma produced by the gun show the existence of two plasma bunches propagating at very different velocities. The faster bunch has 20 to 40 kev of longitudinal energy and 1 kev of mean transverse energy. The number of ions in

this bunch is of the order of $5 \times 10^{16}$ and its mean longitudinal speed is $2 \times 10^{8}$ cm/sec. (D.C.W.)

**28780** DETERMINATION OF THE CONCENTRATION OF CHARGED PARTICLES AND NEUTRAL ATOMS BY SELF-INVERTED CONTOURS OF SPECTRAL LINES IN PLASMA. L. I. Grechikhin (Inst. of Physics, Academy of Sciences, Belorussian, SSR). High Temp., 1: 176-80(Sept.-Oct. 1963). (Translated from Teplofiz. Vysokikh Temp., 1: 198-202(Sept.-Oct. 1963)).

The possibility of determining the inhomogeneity parameter of a source by using any self-inverted pair of spectral lines is demonstrated. Using the Li 6103.64 Å line, it is possible simultaneously to determine the concentration of absorbing (neutral) atoms and charged particles (electrons). The concentration of neutral Li atoms and the electron concentration in the plasma of a direct current arc were measured. (auth)

**28781** COMPLEX CONDUCTIVITY AND THE STABILITY OF IONIZED GASES. A. F. Nastoyashchii. High Temp., 1: 181-8(Sept.-Oct. 1963). (Translated from Teplofiz. Vysokikh Temp., 1: 203-11(Sept.-Oct. 1963)).

An investigation was made on the hydrodynamic theory of the conductivity of plasma with an arbitrary degree of ionization. The high-frequency conductivity tensor was calculated for spatially nonuniform ionized gas. The tensor is a differential operator and depends on the flow of charged particles as well as on the heat flow. It is important that the dependence of the conductivity tensor (and consequently, the oscillations and stability of the plasma) on the heat flow in the gas appear in the hydrodynamic equations only if the law of scattering of charged particles is taken into account and can not be obtained within the framework of the phenomenological equations of hydrodynamics ordinarily used. It is noted that the law of scattering has a strong effect on the transport processes in ionized gas. Expressions are presented for complex conductivity in which the contribution of electrons and ions is accounted for in the case of plasma in an electric field. The stability of ionic sound in a gas consisting of electrons, ions, and atoms, was investigated, taking the wave motion of atoms into account. When the drift velocity of electrons is greater than the phase velocity $kv_e > \omega$, the viscosity of the electron gas changes sign and this leads to an increase of ionic sound oscillations. Collisions of ions with atoms and the heat conductivity of electron gas lead to additional damping of oscillations. The increments of the amplitude (damping decrements) of the waves were calculated. (P.C.H.)

**28782** DETERMINATION OF THE THERMODYNAMIC PROPERTIES AND THE COMPOSITION OF MIXTURES OF GASES AT HIGH TEMPERATURES. E. V. Samuilov (Krzhizhanovskii Energy Inst., USSR). High Temp., 1: 189-95(Sept.-Oct. 1963). (Translated from Teplofiz. Vysokikh Temp., 1: 212-17(Sept.-Oct. 1963)).

A method is described for determining the composition of plasma consisting of an arbitrary number of different kinds of atoms in the case of a high degree of ionization of atoms and also a method of determining the thermodynamic properties of the plasma. In all calculations, the effect of Coulomb fields of ions and electrons on the surrounding particles and the effect of radiation on the properties of ions were neglected. (auth)

**28783** AN ULTRASONIC METHOD FOR DETERMINING ELECTRON AND ION TEMPERATURES OF PLASMA. V. P. Bhatnagar (Maulana Azad Coll. of Tech., Bhopal, India). Indian J. Pure Appl. Phys., 2: 160-2(May 1964).

A method of determining electron ($T_e$) and ion ($T_i$) temperatures of an ionized gas plasma is given. The temperatures $T_e$ and $T_i$ were evaluated from measured values of the reflection coefficients of the gas plasma for ultrasonic waves at two frequencies, one a low frequency and the other a high frequency comparable to the electron-plasma frequency. The formulas relating $T_e$ or $T_i$ with the reflection coefficients were derived from the single-fluid model of plasma with certain simplifying assumptions. The necessary modification in the formulas and the method of evaluation of the temperature in the case of sheet plasmas and low temperature plasmas are also discussed. (auth)

**28784** ELECTRODE BOUNDARY LAYERS IN DIRECT-CURRENT PLASMA ACCELERATORS. Jack L. Kerrebrock (California Inst. of Tech., Pasadena). J. Aero/Space Sci., 28: 631-43(Aug. 1961).

One of the problems that must be faced in the development of direct-current plasma accelerators is that of boundary-layer growth on the electrode surfaces. These surfaces must be maintained at a somewhat lower temperature than is desirable in the bulk of the gas flow. The associated reduction in electric conductivity near the electrode surface, together with the continuous current through the boundary layer, may result in greatly augmented Joule heating near the surface, and increased heat transfer. This phenomenon is treated within the framework of boundary-layer theory. It is found that similar solutions for the thermal and viscous boundary layers exist for a certain class of accelerated flows in which the velocity varies as a power of the steamwise coordinate. The solutions show that the heat-transfer rate at Mach numbers near unity may be as much as ten times that which would be expected for a normal boundary layer. At higher Mach numbers, the similarity is not precisely valid; however, the analysis indicates qualitatively that a stagnation enthalpy overshoot may occur in the high-temperature portion of the boundary layer as a result of the electromagnetic acceleration. (auth)

**28785** ON THE RELAXATION IN THE ELECTRICAL CONDUCTIVITY OF PLASMAS AND ELECTROLYTES. H. T. Davis and P. Resibois (Universite Libré, Brussels). J. Chem. Phys., 40: 3276-92(June 1, 1964).

The general formalism developed by Prigogine is applied to transport in plasmas and electrolytes. Taking into account the collective effects due to the long-range character of Coulomb forces, an exact transport equation for a dilute plasma is first obtained and is then generalized to an electrolyte using a semiphenomenological description of the solvent. Special attention is given to the internal field effect, which is shown to result from the interference between the external field and the collision processes. In simple cases, good agreement is obtained with the Debye-Onsager limiting laws. (auth)

**28786** MAGNETIC COMPRESSION OF TOROIDAL PLASMA. Tadashi Kawai, Hiromichi Kondo, Moriyuki Sugimoto, Masatami Iwamoto, Katsushi Toshioka, and Toshio Tobita. Mitsubishi Denki Lab. Rept., 4: 433-55 (Oct. 1963).

The possibility of confining the plasma in a toroidal shape by means of axial magnetic field with a high rate of rise was investigated. The plasma column in the glass torus was pre-heated with the induced axial current by ohmic heating before it was adiabatically compressed. A high degree of uniformity of the electromagnetic field in the torus was provided. The plasma of air or He was constricted to about ⅓ of the torus inner diameter, for 10 to

20 μsec, after which the drift of the column due to the charge separation was observed to drive it toward the wall. The temperature was estimated from the plasma conductivity to reach 100,000 to 200,000°K. Magnetic probe and spectroscopic diagnostics were also applied. (auth)

**28787** THEORY OF RADIATION EMISSION AND ABSORPTION IN PLASMA. Thomas D. Dupree (Massachusetts Inst. of Tech., Cambridge). Phys. Fluids, 7: 923-40 (July 1964).

Starting with the basic plasma kinetic equations correct to second order in the plasma parameter, general formulas for cyclotron and bremsstrahlung emission and absorption are derived. The theory provides a rigorous description of the interaction of plasma and radiation. At equilibrium, Kirchhoff's law is recovered and the theory reduces to previously derived results. (auth)

**28788** KINETIC EQUATIONS FOR A PLASMA INCLUDING RADIATION IN THE PRESENCE OF AN EXTERNAL MAGNETIC FIELD. Ronald Fante (Princeton Univ., N. J.). Phys. Fluids, 7: 940-8(July 1964).

The solutions of the Simon–Harris hierarchy of equations for a spatially homogeneous plasma in an external magnetic field are obtained by an operator technique. These solutions are then used to formally derive a Fokker–Planck equation and what may be interpreted as a radiative transfer equation. Finally the solutions for the limiting case of zero magnetic field are obtained and examined. (auth)

**28789** NORMAL MODES FOR ELECTROSTATIC ION WAVES IN AN INHOMOGENEOUS PLASMA. Francis F. Chen (Euratom-CEA, Fontenay-aux-Roses, France). Phys. Fluids, 7: 949-55(July 1964). (MATT-227)

The propagation of low-frequency electrostatic oscillations perpendicular to a density gradient in a low-density, fully ionized plasma in a strong magnetic field B is studied from the point of view of the linearized macroscopic equations. Two sets of waves are found in the limits where the electrons move freely along B or not at all along B. Among these are waves which travel at the electron and ion diamagnetic drift velocities, and a physical description of this phenomenon is given in terms of microscopic motions. The transition between these two sets of modes occurs at angles of propagation very close to 90° to B; to treat this region of angles one must take into account either the electron inertia or the plasma resistivity. Dispersion curves are given for this transition region. In addition, it is found that in a small range of angles one of the cyclotron waves and the wave traveling near the electron drift velocity are unstable and can be excited by the pressure gradient, even if no longitudinal currents exist in equilibrium. (auth)

**28790** INSTABILITIES DUE TO RESISTIVITY GRADIENTS IN A LOW-PRESSURE PLASMA. F. C. Hoh (Univ. of California, San Diego, La Jolla). Phys. Fluids, 7: 956-64(July 1964).

Instabilities due to resistivity gradients in a low-pressure plasma are reconsidered using the electrostatic approximation. The fastest growth rate is proportional to $\eta_{||}^{1/3}$, where $\eta_{||}$ is the resistivity component parallel to the magnetic field. Contrary to earlier belief, heat conductivity along the field lines does not reduce the growth rate appreciably for Stellarator type of data. This mode is strongly localized in a thin layer inside the plasma, and hence may not produce much anomalous diffusion. Comparison is made with the much slower Kadomtsev mode, proportional to $\eta_{||}$, which is not localized. The effects of finite Larmor radius and Hall current acting in the plane perpendicular to the magnetic field are deduced. The corresponding actions parallel to the magnetic field, which seems to be more important when the plasma pressure is not too low, is not considered. (auth)

**28791** MICROWAVE PROPAGATION IN AN OVERDENSE BOUNDED MAGNETOPLASMA. Bernard Wieder (National Bureau of Standards, Boulder, Colo.). Phys. Fluids, 7: 964-72(July 1964).

In the last few years experiments were reported which demonstrated propagation of electromagnetic waves through an overdense magnetoplasma, i.e., a plasma whose plasma frequency is greater than the frequency of the probing wave. The interpretation of the experimental results was based on the whistler mode. The whistler mode appears in the infinite plane wave solutions of Maxwell's equations for an infinite homogeneous magnetoplasma. In a laboratory plasma, the effects of the boundaries of the plasma may play an important role in determining the propagation properties of the waves. These effects are examined and the analysis shows that the waves may, under certain circumstances, exhibit sufficiently different qualitative and quantitative characteristics to seriously limit the applicability of the infinite medium theory to bounded plasmas. To illustrate this point, the properties of waves propagating in a dense, homogeneous, cylindrical plasma bounded by a conducting wall are examined and compared with the properties of the wave predicted from infinite plane wave theory. (auth)

**28792** ELECTRON-ION RELAXATION TIMES. S. Rand and F. Albini (Inst. for Defense Analyses, Washington, D. C.). Phys. Fluids, 7: 972-6(July 1964).

The approach to equilibrium of the electron and ion components of a plasma was studied. The interactions between particle pairs are determined in a polarizable plasma, so that collective effects are included at the outset. The pairwise interactions are treated quantum mechanically, in the Born approximation, whereas the collective effects are, in a consistent manner, treated classically. Corrections to previously quoted results, due to the proper inclusion of shielding, as well as quantum effects, are logarithmic. (auth)

**28793** ON THE PRODUCTION OF PLASMA BY GIANT PULSE LASERS. John M. Dawson (Princeton Univ., N. J.). Phys. Fluids, 7: 981-7(July 1964).

Calculations are presented which show that a laser pulse delivering powers of the order of $10^{10}$ w to a liquid or solid particle with dimensions of the order of $10^{-2}$ cm will produce a hot plasma with temperatures in the range of several hundred ev. To a large extent the plasma temperature is held down by its rapid expansion and cooling. This converts much of the energy supplied into ordered energy of expansion. This ordered expansion energy can amount to several kev per ion. If the expanding plasma can be caught in a magnetic field and its ordered motion converted to random motion this might be utilized as a means for filling controlled thermonuclear fusion devices with hot plasma. Further, it should also be possible to do many interesting plasma experiments on such plasmas. (auth)

**28794** EXPERIMENTAL AND THEORETICAL STUDIES OF INSTABILITIES IN A HIGH-ENERGY NEUTRAL INJECTION MIRROR MACHINE. L. G. Kuo, E. G. Murphy, M. Petravić, and D. R. Sweetman (United Kingdom Atomic Energy Authority, Abingdon, Berks, Eng.). Phys. Fluids, 7: 988-1000(July 1964). (CLM-P-32)

Recent observations with the Phoenix high-energy neutral injection experiment are described. At densities where the

electron plasma frequency is greater than the ion cyclotron frequency, strong emission at the ion cyclotron frequency and $\frac{1}{2}$ the ion cyclotron frequency is observed. This is interpreted on the basis of the theory of electrostatic instability developed by Harris and others. Experimentally, the instability results in strong scattering of ions out of the transverse direction but so far as can be observed, there is no actual loss of plasma. Above a density of $5 \times 10^8$ particles/cm$^3$, accumulation of particles is limited by the development of strong low-frequency (~100 kc) oscillations which appear to be an m = 1 displacement of ions and electrons rotating at half the ion precession frequency. This mode is approximately independent of density. During periods of strong emission at the ion cyclotron frequency, however, another mode is observed, the frequency of which is approximately proportional to density. These observations suggest an m = 1 precessional drift instability. The existing theories concerning this low-frequency instability are fully discussed. A new calculation in which the cylindrical plasma shape and the associated boundary conditions are taken into account is presented. Its predictions are in reasonable agreement with experiment. The electric field inside the plasma is found to be nonuniform even for the m = 1 mode, so that finite Larmor radius effects are to be expected for this mode, contrary to common belief. The full equation for the electric potential valid for all densities and including the first order finite Larmor radius effect is presented. However, the finite Larmor radius effect is found to be small at densities around $10^8$ particles/cm$^3$, and at magnetic fields above 10 kG. (auth)

**28795** CLASSICAL AND ENHANCED DIFFUSION IN CESIUM AND POTASSIUM PLASMAS. N. Rynn (Princeton Univ., N. J.). Phys. Fluids, 7: 1084-6(July 1964). (MATT-259)

The measurement of the classical diffusion in a fully ionized cesium and potassium plasma column in a magnetic mirror machine is reported. It was observed that the passage of a current through the plasma had a large effect upon the diffusion rates. The reciprocal of the relaxation length and the reciprocal of the diffusion coefficient were plotted as a function of the magnetic field for stable and unstable conditions. (C.E.S.)

**28796** DIFFUSION OF A CESIUM PLASMA IN A MAGNETIC FIELD. Nicola d'Angelo (Princeton Univ., N. J.). Phys. Fluids, 7: 1086-7(July 1964).

Diffusion of a highly ionized cesium plasma across a magnetic field in a magnetic mirror machine was investigated. The density was plotted as a function of magnetic field and as a function of ion density. The results are discussed with respect to classical diffusion theory. (C.E.S.)

**28797** EXACT SOLUTION OF THE DIFFERENTIAL EQUATION FOR THE NONDIVERGENT CORRELATION FUNCTION IN A ONE-COMPONENT PLASMA. G. L. Lamb, Jr. (United Aircraft Corp., East Hartford, Conn.) and B. Burdick. Phys. Fluids, 7: 1087-8(July 1964).

A previously developed differential equation for a one-component plasma which exhibits no divergence for any impact parameter is discussed. It is shown that this equation may be transformed to the standard form of the Mathieu equation. It is also shown that the solution for large and small impact parameters may be joined exactly without introducing an intermediate region on the order of the interparticle distance. (C.E.S.)

**28798** "TEST PARTICLE" PROBLEM FOR AN EQUILIBRIUM PLASMA. D. A. Tidman, R. L. Guernsey, and D. Montgomery (Univ. of Maryland, College Park). Phys. Fluids, 7: 1089-91(July 1964).

A Fokker-Planck equation for a test particle distribution is derived from the many-species Balescu-Lenard equation. The friction and dispersion coefficients are reduced to simple expressions for fast test particles and compared with those previously calculated by other methods. (C.E.S.)

**28799** SUPPRESSION OF HELICAL INSTABILITIES IN PLASMA BY HIGH MAGNETIC FIELDS. Harry S. Robertson (Univ. of Miami, Coral Gables, Fla.). Phys. Fluids, 7: 1093-4(July 1964).

The return to stability in cesium arc plasma at magnetic field strengths of the order of twenty times the critical field for the onset of helical instability was investigated. The plasma becomes confined well away from the wall, and then the axial electric field decreases to a value less than that before the onset of instability indicating a reduced rate of energy dissipation at constant current and therefore presumably a reduced plasma loss rate. Pronounced hystereses are observable in both the high and low magnetic field regions. (C.E.S.)

**28800** COMMENTS ON "GRAVITATIONAL RESISTIVE INSTABILITIES IN PLASMA WITH FINITE LARMOR RADIUS." Bruno Coppi (Stanford Univ., Calif.). Phys. Fluids, 7: 1096-7(July 1964).

The effects of ion gyration radius on gravitational resistive instabilities in plasma are discussed. A set of macroscopic equations derived from the Fokker-Planck equation are used. It is shown that the width of the region where the Larmor radius and the resistivity are important is essentially controlled by the Larmor radius and not by the resistivity and the wavelength of the perturbation. It is also shown that the frequency of oscillation does not depend on resistivity and that the growth rate is independent of the wavelength. (C.E.S.)

**28801** OBSERVATION OF EARLY PLASMA ROTATION IN A SLOW THETA PINCH. E. H. Beckner and J. R. Banister (Sandia Lab., Albuquerque, N. Mex.). Phys. Letters, 10: 56-7(May 15, 1964).

A slow, low-energy $\theta$-pinch experiment with helium is discussed. The plasma is observed to rotate early in time with the direction of rotation that of ion orbital motion in the magnetic field. It is concluded that the rotation does not arise from tensor conductivity effects but is a phenomena associated with the radial electric field that arises from charge separation phenomena. (C.E.S.)

**28802** CONTINUOUS ACCELERATION OF PLASMA IN ELECTROMAGNETIC AND STATIC MAGNETIC FIELD GRADIENTS. EXPERIMENTAL RESULTS. R. Bardet, T. Consoli, and R. Geller (CEN, Saclay, France). Phys. Letters, 10: 67-9(May 15, 1964). (In French)

The gases accelerated were H, He, N, and Ar. The influence of the static magnetic field is described for two characteristic compression conditions—for a fixed slope of the magnetic field gradient but variable absolute values of the cavity magnetic field, and for an increased magnetic field, taking account of the relativistic variation of the electron mass and achieving the equality $\omega_{ce} = \omega_{hf}$ nearest the center of the cavity. Sample gas-flux and energy yields are given. The electron energy spectrum is surveyed. A Langmuir probe was used to verify experimentally one of the theoretical provisions about the transversal distribution of the ions and electrons in the plasma cluster. (M.J.T.)

**28803** NONLINEAR INTERACTION OF AN ELECTROMAGNETIC WAVE WITH A PLASMA LAYER IN THE PRESENCE OF A STATIC MAGNETIC FIELD. III. THEORY OF MIXING. E. B. Barrett, R. F. Whitmer, and S. J. Tetenbaum (Lockheed Missiles and Space Co., Palo Alto, Calif.). Phys. Rev., 135: A369-73(July 20, 1964).

The Boltzmann transport equation coupled with Maxwell's equations was solved under a small signal, plane-wave assumption for a uniform, weakly ionized plasma layer with a constant collision frequency in the presence of a static magnetic field. The effects of the nonlinear terms in the equations are included. The amplitudes of the sum and difference frequency waves produced within the plasma layer by two incident waves of different frequencies, which propagate in the extraordinary mode within the plasma, are derived as functions of the plasma and incident wave parameters. Resonances in the amplitudes of these waves occur for values of the static magnetic field in the neighborhood of plasma resonance for the waves at the fundamental and combination frequencies. The magnetic-field strength for which a given resonance occurs is a sensitive function of the electron density. This provides a mechanism through which the electron density in a plasma layer can be determined by a measurement of magnetic-field strength. (auth)

**28804** NONLINEAR INTERACTION OF AN ELECTROMAGNETIC WAVE WITH A PLASMA LAYER IN THE PRESENCE OF A STATIC MAGNETIC FIELD. IV. EXPERIMENTAL RESULTS. S. J. Tetenbaum, R. F. Whitmer, and E. B. Barrett (Lockheed Missiles and Space Co., Palo Alto, Calif.). Phys. Rev., 135: A374-81(July 20, 1964).

The nonlinear interaction of an electromagnetic wave with a uniform, weakly ionized anisotropic plasma layer was investigated experimentally. The experiment was designed to comply as closely as possible with the assumptions used in the theory of the nonlinear interaction. Experimental results on sum and difference frequency mixing and harmonic generation are described as a function of the ambient electron density, the electron-neutral particle collision frequency, the external d-c magnetic-field strength, thickness of the plasma layer, and the field strengths and frequencies of the incident waves. The case of linearly polarized, small-amplitude microwave signals incident on a layer of helium plasma is examined. Within the plasma, the signals propagate as plane waves with their directions of propagation and polarization normal to the d-c magnetic field (i.e., the extraordinary mode of propagation). A detailed comparison is made between the experimental results and the theoretical predictions. Quantitative agreement was obtained over the electron density range permitted by the experiment. The results show that the plasma model assumed in the theory is an accurate representation of the actual plasma, and that the small-signal analysis accurately predicts the effects of the nonlinear terms in the Boltzmann equation on propagation phenomena. However, special care is required to insure that the plane-wave, infinite-medium assumption employed in the theory is satisfied experimentally. The experimental results also establish the validity of using certain characteristics of the nonlinear phenomena as a tool for measuring the electron density in a plasma. A resonance was detected in the sum frequency wave which is not predicted by the theory. This resonance occurs for values of the d-c magnetic-field strength corresponding to cyclotron resonance at the arithmetic mean of the two incident frequencies. The origin of this resonance is not understood at this time. (auth)

**28805** BALL LIGHTNING. David Finkelstein and Julio Rubinstein (Yeshiva Univ., New York). Phys. Rev., 135: A390-6(July 20, 1964).

A plasmoid model for ball lightning is examined. The usual virial theorem shows that confinement by self-field alone is inconsistent with conservation laws for energy and momentum; a generalization shows that the presence of air pressure removes this inconsistency and gives an upper bound to the stored energy. This upper bound is much less than the energies reported for some occurrences. For permissible energies the kinetic temperature and density of the plasma can be chosen so that it will not be degraded by internal Coulomb collisions or dissipated by cyclotron radiation for some seconds. It is however necessary to insulate the plasma from the air. A self-field that is able to do this will give up the total stored energy to ohmic heat in the air boundary in a much shorter time than is reported. It is concluded that the plasmoid model is impossible and that energy must be supplied to the ball during its existence if the order of magnitude of the reported energies and times are accepted. Therefore a new model is examined. The high d-c electric fields associated with lightning storms are invoked as energy source, and an idealized nonlinear conduction problem is shown to admit ball-like solutions. This leads to a ball lightning model of a low-current glow discharge in an atmospheric d-c field. A region of higher conductivity results in a local increase of the electric field and current density sufficient to produce a glow discharge, which provides the higher conductivity and is thus self-consistent. If this model is appropriate, then ball lightning has no relevance to controlled-fusion plasma research. (auth)

**28806** EXCITATION OF LONGITUDINAL PLASMA OSCILLATIONS NEAR ELECTRON CYCLOTRON HARMONICS. S. J. Buchsbaum and A. Hasegawa (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev. Letters, 12: 685-8(June 22, 1964).

The observed properties of resonance microwave absorption and emission in a plasma column near the harmonics of the electron cyclotron frequency are presented and their theory is developed. The resonances are attributed to excitation of longitudinal plasma oscillations within narrow pass bands near each cyclotron harmonic. It is shown that, as in the case of oscillations in the absence of a magnetic field, the dispersion relation and the nature of the oscillations are profoundly modified by density gradients. (M.J.T.)

**28807** NEW DEVELOPMENTS IN THE FIELD OF MAGNETOHYDRODYNAMICS. I. PHYSICAL PRINCIPLES. Emil Pfender (Technische Hochschule, Stuttgart). Umschau Wiss. Tech., 64: 289-92(May 15, 1964). (In German)

Developments in magnetohydrodynamic (MHD) research are discussed, including the concept of direct energy conversion using a MHD generator and uses in space flight technology. The concept of plasma is defined and properties of a plasma are described. The induction law on which MHD generators are based and the principles of MHD-generator operation are discussed. The role of the Hall effect in MHD generators is also considered. (M.C.G.)

**28808** ON THE STRUCTURE OF SHOCK WAVES IN A PLASMA. B. A. Tverskoi (Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 46: 1653-63(May 1964). (In Russian)

Formulas for the stationary motion of a plasma perpendicular to the magnetic field are derived by taking into account dissipation. The structure of the shock wave is considered for the cases of collisional dissipation and electron

beam instability. In the first case the wave is of the usual type and on both sides of its front the conditions of freezing in of the field, and continuity of matter, momentum, and energy fluxes are fulfilled. In the second case there is a narrow front on which dissipation occurs. Behind the front a periodic (but not rigorously sinusoidal) magnetoacoustic wave is propagated along the heated plasma in which beam instability is absent. (auth)

**28809** RADIATION OF TRANSVERSE ELECTROMAGNETIC WAVES DUE TO SCATTERING OF CHARGED PARTICLES ON PLASMA WAVES. A. Gailitis and V. N. Tsytovich. Zh. Eksperim. i Teor. Fiz., 46: 1726-39(May 1964). (In Russian)

It is shown that the emission of transverse waves by superthermal electrons occurs in the field of a plasma wave as a result of dipole radiation due to oscillations of the electron in the wave as well as a result of traversal by the electron of density inhomogeneities, created by the plasma wave. Emission of transverse waves by electrons is forbidden in the nonrelativistic case (v = 0) by interference of the two effects. The forbiddenness does not hold for particles with masses differing from that of the electron. The radiation spectrum of electrons and ions in a broad energy range from nonrelativistic to relativistic energies is calculated. The graph technique is used for calculating quantum effects which become significant for secondary quantum energies close to the energy of the charged particles. Possible astrophysical applications are discussed as well as the possibility of determining the particle energy and mean energy density of the plasma waves on basis of the intensity of the radiation. It is also shown that the frequencies of transverse waves produced in scattering of cosmic ray electrons on plasma waves may considerably exceed the frequency of waves produced by the synchrotron mechanism. (auth)

**28810** THEORY OF NONSTATIONARY FINITE AMPLITUDE WAVES IN A RAREFIED PLASMA. Yu. A. Berezin and V. I. Karpman (Novosibirsk State Univ., USSR). Zh. Eksperim. i Teor. Fiz., 46: 1880-90(May 1964). (In Russian)

Nonstationary waves of finite (but small) amplitude which propagate in a cold plasma at an angle or perpendicular to a magnetic field are investigated. Approximate equations for such waves are obtained. Nonstationary solutions of the equations are deduced which describe the waves at large distances from a source operative during a finite period of time. (auth)

**28811** INVESTIGATION OF GAS-DISCHARGE AND COSMIC PLASMA WITH THE AID OF MULTIELECTRODE PROBES (SURVEY). N. I. Ionov (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Tekhn. Fiz., 34: 769-87(May 1964). (In Russian)

A survey is made of probe methods for studying characteristics of gas-discharge and cosmic plasmas having a relatively small particle concentration. Measurements using one through four probes are discussed for stationary and cosmic plasmas. Data such as charged-particle concentration and kinetic energy, unperturbed-plasma potential, and the plasma potential gain may be obtained. (M.J.T.)

**28812** ON THE STABILITY OF A PULSATING PLASMA CYLINDER. Yu. V. Vandakurov (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Tekhn. Fix., 34: 788-800(May 1964). (In Russian)

Distributions of the magnetic field, the density, and other variables in the stationary state and the stability of an infinite plasma cylinder, placed in a strong longitudinal magnetic field which oscillates around a mean value, were studied in the magnetohydrodynamic approximation. It is assumed that the magnetic pressure is large in comparison with the plasma pressure and the pulsation period is small with respect to the characteristic times of thermal and directional motion in the plasma. Only perturbations with a wavelength longer than the cylinder radius are considered. (tr-auth)

**28813** THE SPECTRUM OF SURFACE WAVES ON A VACUUM–MAGNETOACTIVE PLASMA BOUNDARY. T. L. Vinnikova and M. A. Gintsburg. Zh. Tekhn. Fiz., 34: 818-20(May 1964). (In Russian)

The roots of the dispersion equation for the phase velocity of surface waves on the boundary between two semi-infinite media—a vacuum and a plasma in a magnetic field—were calculated by computer. An expression for the frequency upper bound is derived, and values are presented in terms of the thermal velocity. Relations among the plasma atomic number, the wave phase velocity, and the absolute velocity are discussed. (M.J.T.)

**28814** ON THE ELECTRON ENERGY DISTRIBUTION FUNCTION IN A POSITIVE DISCHARGE COLUMN. Yu. M. Kagan and R. I. Lyagushchenko (Leningrad State Univ.). Zh. Tekhn. Fiz., 34: 821-7(May 1964). (In Russian)

The question of the electron energy distribution function in the positive column of a plasma is considered, taking into account interactions between electrons, elastic collisions with atoms, and inelastic collisions of the first and second kind. The derived distribution functions converge much more quickly than a Maxwellian distribution at high energies. (tr-auth)

**28815** ON THE ELECTRON VELOCITY DISTRIBUTION FUNCTION IN THE POSITIVE COLUMN IN A MIXTURE OF GASES. N. A. Vorob'eva, Yu. M. Kagan, and V. M. Milenin (Leningrad State Univ.). Zh. Tekhn. Fiz., 34: 828-32(May 1964). (In Russian)

In mixtures of mercury and inert gases, derivations of the electron velocity distribution from Maxwellian were found in the region of fast electrons. (tr-auth)

**28816** INVESTIGATION OF THE BEHAVIOR OF A PLASMA IN A MAGNETIC TRAP WITH AXIAL CURRENT (SYSTEM N). I. M. Podgornyi and V. N. Sumarokov. Zh. Tekhn. Fiz., 34: 833-40(May 1964). (In Russian)

Preliminary results, relating to the injection of plasma clusters into a trap with axial current and to the heating of plasma by axial-current fields increasing with time, are presented. The data indicate growth of plasma temperature upon compression by a field of axial current. The measured plasma temperature agrees with calculations based on analysis of the behavior of the spectral-line intensity in time. The temperature dependence on current is found to be weaker than when derived from formulas, which assume a simultaneous increase of current in the coils and through the rod. (M.J.T.)

**28817** ELECTRODE CONICAL SOURCE OF PLASMA CLUSTERS WITH IMPULSE OVERLAPPING OF GAS. Yu. S. Azovskii, I. T. Guzhovskii, and B. G. Safronov. Zh. Tekhn. Fiz., 34: 841-6(May 1964). (In Russian)

An electrode conical source with a spiral current conductor was examined. The velocity of the plasma clusters ejected from the source increased linearly with the voltage in the capacitor battery and equals (3 to 8) × $10^5$ cm/sec at 6 to 15 kv. The density of the charged particles, estimated by the microwave signal cutoff method ($\lambda$ = 8 mm), appeared greater than 1.7 × $10^{13}$ $cm^{-3}$. The mass composition

of the clusters was determined with the aid of the Thomson mass-analyzer. Depending on the conditions of the discharge (the battery voltage, the quantity of hydrogen injected into the source), the quantity of hydrogen in the cluster amounted to 70 to 90%. The remaining heavy impurities were carbon and oxygen—from diffusion-pump oil vapors. (tr-auth)

**28818** ACHIEVEMENT OF FAST PLASMA CLUSTERS USING A COAXIAL SOURCE. A. G. Belikov, V. P. Goncharenko, V. M. Mischenko, B. G. Safronov, and A. S. Slavnyi. Zh. Tekhn. Fiz., 34: 847-52(May 1964). (In Russian)

The parameters of a fast cluster are investigated. Conditions were found at which plasma clusters with speeds of 8 to $9 \times 10^7$ cm/sec and density not less than $10^{13}$ cm$^{-3}$ could be obtained from a coaxial source. Using a mass-spectrographic method, it was confirmed that particles in the cluster are distributed in a wide energy interval. (At average deuterium ion energy on the order of 8 kev, maximum energy reaches 20 kev.) Relations among cluster speed, energy, delay time, and source voltage are presented. The full number of fast ions in the plasma cluster was calculated. (M.J.T.)

**28819** RADIATION OF THE PLASMA JET OF AN IMPULSE DISCHARGE. V. K. Semenov and L. A. Spektorov (Kirgiz State Univ., USSR). Zh. Tekhn. Fiz., 34: 853-6 (May 1964). (In Russian)

A plasma jet, flowing from a narrow channel through which a battery of capacitors with C = 300 μf and U = 2800 v was discharging, was investigated. In the jet was detected a region of intensive recombination and fluorescence with a temperature near 30,000°K. The jet had a stable laminar structure with alternate bright and dark layers. (tr-auth)

**28820** IONIZATION AND CAPTURE OF ELECTRONS UPON THE COLLISION OF HYDROGEN IONS WITH THE ATOMS AND MOLECULES OF A GAS. Yu. S. Gordeev and M. N. Panov (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Tekhn. Fiz., 34: 857-60(May 1964). (In Russian)

Cross sections for ionization and electron capture by the ions $H_1^+$, $H_2^+$, and $H_3^+$ in hydrogen, nitrogen, and argon in the energy range 1 to 40 kev were measured. The data obtained on the cross sections agree with results from other experiments. (tr-auth)

**28821** PROCESSES IN ELECTRODES DURING A VERY PRECISE DISCHARGE IN A VACUUM. S. V. Gurov, T. A. Dzhafarov, A. A. Malinin, B. A. Osadin, and Yu. F. Tainov. Zh. Tekhn. Fiz., 34: 868-72(May 1964). (In Russian)

Experiments on the study of a low-voltage, very precise discharge in a vacuum are described. With the aid of a fast photograph, it appears that the burst of electrode material at the time of the discharge proceeds in the form of separate, spatially limited plasma formation—microplasmoids. The plasmoid speeds were recorded at 1 to $2 \times 10^6$ cm/sec. By the method of microsections, the presence of microcraters on the surface of the cathode was established. Their dimensions were determined. (tr-auth)

**28822** CONTAINMENT OF A DENSE PLASMA WITH A CURRENT IN A MAGNETIC FIELD. L. L. Pasechnik, O. V. Kozak, and V. V. Yagola (Inst. of Physics, Kiev). Zh. Tekhn. Fiz., 34: 873-8(May 1964). (In Russian)

The radial distribution of charge concentration was experimentally investigated in a dense ($10^{12}$ to $10^{14}$ cm$^{-3}$) quasistatic plasma created by an intensive electron flux. The plasma was in a longitudinal magnetic field of intensity up to 7 kgauss. The experimental results are in good agreement with the theory, on the basis of which rest the representations of the resolving role of diffusion for the calculation of electron-ion collisions taking into account volume recombination. (tr-auth)

**28823** ON THE THEORY OF AN ELECTRIC ARC COLUMN, BURNING IN CONDITIONS OF NATURAL CONVECTION. [PART] I. I. A. Krinberg (Inst. of Geochemistry, Academy of Sciences, Siberian SSR). Zh. Tekhn. Fiz., 34: 888-95(May 1964). (In Russian)

An approximate solution of the equation for energy balance in an arc column is found, permitting the computation of the remaining column parameters if the composition and properties of the arcing plasma are known. On the basis of the relation obtained, an explanation is proposed for the independence of the forms of electric-conductivity radial distribution from the current and the plasma composition. The results achieved may prove useful in investigations in the realm of electric-welding spectral analysis and also in radiation properties of low-temperature plasma. (tr-auth)

**28824** ON THE THEORY OF A DIODE FILLED WITH RAREFIED PLASMA. F. G. Baksht. Zh. Tekhn. Fiz., 34: 926-39(May 1964). (In Russian)

A survey is made of work on low-pressure plasma diodes with one potential maximum in the space between the electrodes, when the gap coating and the potential-well depth are small in comparison to ckT/e, and the wells are filled by charged particle scattering on neutral atoms. The limiting cases are considered, when the velocity distributions of neutral atoms correspond to a Maxwell distribution (at the cathode temperature) and when they are at rest. In addition, the filling of the well with ions upon their charge exchange is investigated. (tr-auth)

**28825** SOME PROPERTIES OF A WEAKLY IONIZED THERMAL CESIUM PLASMA. N. D. Morgulis and Yu. P. Korchevoi (Shevchenko State Univ., Kiev). Zh. Tekhn. Fiz., 34: 940-8(May 1964). (In Russian)

An experimental investigation of properties of a thermal cesium plasma, produced in a cylindrical diode by an incandescent filament, was performed. Using the probe method, for cesium-pair pressure 0.01 and 0.1 mm Hg and filament temperatures from 1440 to 1880°K, the radial potential distribution and the concentrations and temperatures of the electrons in this plasma with the initial emf, i.e., in the absence of through current, were determined. For the case of a plasma at rest, bipolar diffusion of charges from the filament to the diode cylinder should take place. Some conclusions about the nature of the phenomena happening here are made on the basis of the data obtained. (tr-auth)

**28826** MICROWAVE DIAGNOSTICS OF ARC-HEATED ARGON PLASMA FLOWS. Richard Currey Warder, Jr. Thesis, Evanston, Ill., Northwestern Univ., 1963. 212p.

An experimental investigation was made on the electrical properties of arc-heated argon plasma flows. Various plasma diagnostic techniques are reviewed and their applicability to the study of plasma flows were examined. The set of equations governing electromagnetic wave propagation in isotropic and anisotropic plasmas was derived and various approximations are presented. Microwave measurements of phase shift, attenuation, ellipticity, and Faraday rotation of isotropic and anisotropic plasmas are described. Experimental electron densities and collision frequencies are presented and comparison with theoretical

predictions of the plasma properties was made. The main conclusion was that the plasma flow is not in equilibrium and that electron-ion collisions are the predominant dissipative mechanism. (Dissertation Abstr., 24: No. 11, 1964)

**28827** RECOMBINATION COEFFICIENTS AND MOBILITIES OF POSITIVE IONS IN THE RARE GASES, HYDROGEN, AND RARE GAS-HYDROGEN MIXTURES. Verlyn Reno Mittelstadt. Thesis, Minneapolis, Univ. of Minnesota, 1963. 95p.

A study was conducted in decaying plasmas where the interacting particles are generally in thermal equilibrium with their environment. The plasma was contained in an X-band microwave cavity. Electron densities were measured by observing the change in the resonant frequency of the cavity caused by the free electron gas. Measurements of the electron density as a function of time during the decay period of pulsed plasmas produced in the rare gases, hydrogen, and rare gas-hydrogen mixtures are presented. In cases where the decrease of the electron decay is exponential as a function of time the mobilities of positive ions can be calculated from the rate of electron loss by ambipolar diffusion. The values of mobility obtained for ions in their parent gas are: $\mu_0(H_3^+) = 13$, $\mu_0(He^+) = 10.7$, $\mu_0(He_2^+) = 16.2$, $\mu_0(Ne^+) = 4.1$, $\mu_0(Ne_2^+) = 6.5$, $\mu_0(A^+) = 1.6$ and $\mu_0(A_2^+) = 1.9$ cm$^2$/volt sec. These values are consistent with those obtained by means of drift mobility measurements. The measured mobilities of hydrogen ions in rare gas-hydrogen mixtures are about 34-42 cm$^2$/volt sec in helium-hydrogen, 17 cm$^2$/volt sec in neon-hydrogen and 6.3 cm$^2$/volt sec in argon-hydrogen. The pressure dependence of the cataphoretic segregation efficiency of neon impurity atoms in helium is demonstrated and explained. Dominance of electron-ion recombination during the afterglow will result in a straight line when the reciprocal of the electron density is plotted versus time. The measured coefficients relating to electron-molecular ion dissociative recombination in helium, neon, argon, krypton, and xenon are presented. The validity of the results was ascertained. The influence on the measurements of the magnitude and duration of the plasma excitation pulse was studied. The recombination coefficient values obtained are: $\alpha_r(He_2^+) \leq 4 \times 10^{-9}$, $\alpha_r(Ne_2^+) = 2.2 \times 10^{-7}$, $\alpha_r(A_2^+) = 6.7 \times 10^{-7}$, $\alpha_r(Kr_2^+) = 1.2 \times 10^{-6}$ and $\alpha_r(Xe_2^+) = 1.4 \times 10^{-6}$ cm$^3$ sec$^{-1}$. These values were independent of gas pressure over the ranges studied. No coefficients relating to electron-ion recombination in hydrogen or the rare gas-hydrogen mixtures could be obtained. However, the rapid rate of electron loss during the early part of the afterflow period indicated that in each case at least one ion had a coefficient of about $10^{-6}$ cm$^3$ sec$^{-1}$ related to it. (Dissertation Abstr., 24: No. 11, 1964)

**28828** PROPAGATION VELOCITIES FOR WAVES IN PLASMA. Robert F. Tooper (Illinois Inst. of Tech., Chicago). p.1-5 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The phase velocity, group velocity, and velocity of energy propagation are calculated for transverse and longitudinal waves in a homogeneous isotropic plasma with no external magnetic field. A linearized two-fluid model consisting of electrons and singly charged positive ions is utilized for the plasma, with collisions taken into account by a momentum-transfer term in the macroscopic equations of motion. At high frequencies the energy velocity for transverse waves approaches the speed of light asymptotically; for longitudinal electron waves it approaches the electron sound velocity. At frequencies near the plasma frequency or below, the energy velocity is a small fraction of the limiting speed for both cases, but is never zero except in the trivial case of zero frequency. For longitudinal ion waves the phase and group velocities approach the ionic sound velocity asymptotically at high frequencies. (auth)

**28829** TEMPERATURE AND COLLISION EFFECTS ON ELECTROMAGNETIC WAVE PROPAGATION IN ANISOTROPIC PLASMAS. V. Bevc and H. Motz (Oxford Univ.). p.7-9 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

It was thought that the shape of the dispersion surfaces in nonattenuating regions of an infinite uniform magnetoplasma may be significantly changed by collision and temperature effects. A detailed study of such deformations is performed to find out when relatively large changes may occur under the influence of relatively small frequencies and thermal speeds. (auth)

**28830** WAVE PROPAGATION IN A BROWNIAN PLASMA. W. A. Janos (Raytheon Co., Waltham, Mass.). p.11-12 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

A charge neutral plasma consisting of electrons, ions, and neutral atoms or molecules is considered. All three species are assumed to be initially at equilibrium and the problem is treated as a near-equilibrium situation. Because of the greater inertia of the ions their mobility is considered negligible for a highly oscillating field. Thus the ions form a uniform background of positive charge in the presence of a propagating electromagnetic wave which is dispersed by electronic reaction. The electronic plasma kinetics are assumed determined by the electromagnetic type of long range interaction between electrons and ions and the short range electron-neutral scattering. Thus the self consistent field alone determines the interaction between charged particles while electron-neutral interaction is treated as a Brownian motion. The kinetic equation contains a linearized Vlasov type of constitutive or field streaming derivative with a Fokker-Planck collision term. Use of the Green's function for the fieldless Fokker-Planck equation transforms the problem into an integral equation, which coincides with the collisionless case in the limit of vanishing viscosity. Collisional correction to the conductivity, field dispersion relation, and index of refraction are obtained in the long wave length limit for transverse and longitudinal modes. Results of Lenard and Bernstein are duplicated for the longitudinal oscillations of a fully-ionized gas by appropriate interpretation of the viscosity coefficient. Direct correspondence is made to the collisionless case as contained in the established literature. (auth)

**28831** GENERALIZED APPLETON-HARTREE THEORY FOR A HOT MAGNETOPLASMA. Hiroshi Kikuchi (Oxford Univ.). p.13-16 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, 1963.

A set of generalized Appleton-Hartree equations for a hot magnetoplasma is presented, including ion dynamics as well as temperature and collisional effects. The theory is based on a rigorous solution of the linearized Boltzmann equation together with Maxwell's equations in terms of Fourier transforms and is developed with the help of a new derivation of the dielectric tensor. For the electromagnetic waves, marked departures from the A-H theory occur near the resonance frequencies, while for the plasma and extraordinary waves, Čerenkov radiation is possible along a resonant cone. When the ion dynamics are included, three kinds of resonances are found, namely ion-cyclotron,

hybrid-cyclotron and ion-harmonic-cyclotron resonance. (auth)

**28832** SOME RESULTS OF CALCULATION OF DISPERSION CURVES INCLUDING COLLISIONS. D. Lepechinsky and F. Parlange (CEN, Saclay, France). p.17-21 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

Dispersion curves including the effect of collisions were calculated with a 7090 IBM computer for several types of laboratory hydrogen plasmas: $T_e = T_i = 1$ ev; $T_e = 1$ ev, $T_i = 0.1$ ev; $T_e = 10$ ev, $T_i = 2$ ev; $T_e = 50$ ev, $T_i = 10$ ev, with neutral gas pressures of $10^{-1}$, $10^{-3}$, and $10^{-4}$ mm Hg and electron densities of $10^{10}$, $10^{13}$, and $10^{15}$/cc. The corresponding collision frequencies with neutrals and between electrons and ions were derived using known relationships. The dispersion equations used correspond to the macroscopic treatment. Re (K) and Im (K) are presented as a function of Re ($\omega$) for electromagnetic and longitudinal waves and for e.m. waves propagating parallel to a permanent magnetic field of 0.5, 10, and 50 kgauss. (auth)

**28833** EXPERIMENTS ON PLASMA RESONANCE. Adam Dattner (Royal Inst. of Tech., Stockholm). p.29-32 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Plasma resonance effects due to the interaction in a waveguide between electromagnetic waves and a plasma cylinder are studied. The plasma densities corresponding to the different peaks of the resonance spectrum are measured. The electron density corresponding to the main resonance is in good agreement with a theory treating the plasma as a homogeneous dielectric. This theory does not account for the other resonances, where the densities show a different dependence on the plasma diameter and on the incident wave frequency. The results are discussed with reference to the theories for the plasma resonances that take into account nonzero plasma electron temperature. (auth)

**28834** RESONANCE IN HOT, FINITE, AND INHOMOGENEOUS PLASMAS. P. E. Vandenplas and A. M. Messiaen (Centre des Sciences Nucléaires, Brussels). p.33-4 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

It is shown that the influence of a glass wall on the secondary resonance spectrum of a hot homogeneous plasma column is negligible. The treatment by Vandenplas and Gould of a hot inhomogeneous plasma, which leads to great computational difficulties, is simplified by adopting a scalar pressure. The characteristic physical parameters are still present. By an appropriate choice of the radial density distribution, bulk effects and possible sheath effects can be investigated. (auth)

**28835** THE PARALLEL PLATE PLASMA PROBLEM WITH A DENSITY VARIATION. R. B. Hall (CEN, Saclay, France). p.35-7 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III. Paris, SERMA, 1963.

The differential equation for one dimensional electron plasma oscillations is found using a hydromagnetic plasma model. The equation is solved for high frequencies with the aid of an analogue computer for the case of parallel-plate boundaries and a sinusoidal dc density distribution. The impedance of the parallel-plate plasma is calculated and shown as a function of the dc density for both high and low frequencies. Representative curves showing the electric field variation with position are given. (auth)

**28836** R. F. THEORY OF THE PLASMA SHEATH. J. Pavkovich and G. S. Kino (Stanford Univ., Calif.). p.39-44 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

A theoretical treatment for the variation of r-f fields within the sheath is given. The analysis is based on an integration of the collisionless Boltzmann equation, with the assumption that the static potential varies parabolically in the sheath. It is shown that an effective impedance for the sheath can be defined, and that over the range in which the numerical results are calculated this impedance always has a real positive part. The real part of this impedance is associated with Landau damping. A set of curves is given of the field through the sheath. (auth)

**28837** THE MECHANISM OF TONKS-DATTNER RESONANCES OF A DISCHARGE COLUMN. F. W. Crawford and G. S. Kino (Stanford Univ., Calif.). p.51-8 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

A mechanism is deduced capable of producing observed plasma-column resonances above the dipole resonant frequency in a transverse electric field. Radial number density variation and finite electron temperature in the column are taken into account. It is assumed that the applied signal is at a frequency above cut-off near to the tube wall, propagates inwards to the point where it is cut off due to the increasing electron density, and then is reflected. At certain penetrations, resonances occur. A limit is reached, when the applied frequency equals the local plasma frequency on the axis, above which there are no further resonances. This is identified as the series limit noted experimentally. Only an approximate derivation of the theory is given. This dose, however approach the measured values. Series of confirmatory experiments were carried out and these accord satisfactorily with the mechanism proposed. (auth)

**28838** ELECTRONIC RESONANCE OF PLASMA. Henri Gutton (Sud-Aviation, Courbevoie, France). p.59-61 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

UHF probing of a plasma is employed for measuring the charge density. By varying the ionization, the presence of an absorption band can be experimentally ascertained. This band appears when the real part of the dielectric constant of the plasma becomes negative. The addition of permanent magnetic field crossed with the electric field of the probe divides the absorption band into two. This experimental fact is not explicable in generally allowed assumptions governing free electrons. Only the action of an internal force, derived from the interaction of positive and negative charges and independent of the probe electromagnetic field, provides an explanation of the division observed. These forces should be measured and taken into conisideration when making density measurements by UHF probes. (auth)

**28839** GYRO-INTERACTION OF MICROWAVES IN MAGNETO PLASMAS IN NOBLE GASES. K. V. Narasinga Rao and L. Goldstein (Univ. of Illinois, Urbana). p.63-8 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The technique of guided electromagnetic-wave interaction in magnetoplasmas was used to study the phenomena resulting from the cyclotron resonance ($f = f_H$ = gyrofrequency of electrons) absorption of microwave energy by the electron gas. The enhancement is electronic energy caused by this

absorption is experimentally evidenced by the study of (1) gyro-interaction of microwaves of different frequencies ($f_1 \leq f_H \leq f_2$), (2) emission of microwave noise power at frequencies $f_n \geq f_H$, (3) intensity of visible light excitation, and (4) rapid disintegration of the plasma. A correlation of these experimental results shows that (1) the rate of heating of any specific region of the plasma changes drastically during different time intervals of the pulsed resonant heating microwave signal and (2) nonuniform heating occurs along the plasma axis. (auth)

**28840** STUDY OF THE PHYSICAL MECHANISM OF ENERGY TRANSFER OF AN ELECTROMAGNETIC WAVE WITH RIGHT CIRCULAR POLARIZATION IN AN IONIZED MEDIUM. T. Consoli, M. Clement, L. Dupas, J. Leron, and M. Weill (CEN, Saclay, France). p.75-9 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

The theory of plasma heating by whistler mode propagation is reviewed. An experiment to study this effect, using PIG discharge with H. F. equipment, is briefly described. Spectroscopic, x-ray, and diamagnetic experimental results are given and discussed. (auth)

**28841** STRONG MICROWAVE-PLASMA INTERACTION. Melvin Epstein (Aerospace Corp., Los Angeles). p.81-5 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The interaction between a plane transverse electromagnetic wave and the slightly ionized flowing gas of a shock wave is described. Mechanisms whereby the energy of the electromagnetic field may be transferred to the plasma are studied. It is found that the dominant mechanism depends on the strength of the applied field. At low power levels the electrons transfer their energy to the neutrals primarily through elastic collisions. At higher power levels the electrons become energetic enough to participate significantly in inelastic collisions. Localized regions of significant ionization enhancement result. The altered electron density and temperature distributions may engender substantial changes in the propagation characteristics of the plasma. In particualr it is found that the reflection coefficient may increase markedly with increased incident power, thereby providing a self-shielding response to intense radiation. (auth)

**28842** THE INTERACTOMETER: A FREE-SPACE MICROWAVE SYSTEM FOR PLASMA DIAGNOSTICS. Thaddeus Kaliszewski (Avco Corp., Wilmington, Mass.). p.87-92 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Construction and operation of a free-space microwave system, operating on the principle of the so-called Luxembourg effect, is discussed. This system, referred to as an interactometer, embodies a laboratory adaptation and extension of techniques used recently for probing the D-layer in the earth's ionosphere. The Luxembourg effect is induced in a small, laboratory sample of plasma by illuminating it with a strong microwave pulse. The resulting alternations in the electron temperature and in the complex index of refraction are then studied with a weak microwave, operated in a dual (pulse and CW) mode. In the pulse mode, measurements are made of the change in amplitude and phase of the weak wave due to interaction; in the CW mode, the energy relaxation constant is measured. The interpretation of these measurements appears to be especially simple for thin, tenuous, homogeneous plasma samples and leads directly to estimates of the electron collision frequency, the fractional energy loss factor, and the ratio of electron density to electron temperature. An example of data generated by an interactometer, operating in the X-band, is used to illustrate the feasibility as well as the potential of the system. (auth)

**28843** GENERATION OF LONGITUDINAL PLASMA WAVES BY MEANS OF TRANSVERSAL ELECTROMAGNETIC WAVES. D. Pfirsch and M. Tutter (Max-Planck-Institut für Physik and Astrophysik, Munich). p.93-9 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The feasibility of generating plasma waves by means of transverse waves in an inhomogeneous magnetic field is treated theoretically. (auth)

**28844** IONIZATION-RECOMBINATION INSTABILITIES. E. G. Harris (Univ. of Tennessee, Knoxville and Oak Ridge National Lab., Tenn.). p.103-6 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Discharges in which gas and electron temperatures may be expected to be equal are considered. The discharge is assumed to occur in the electrode material in the presence of an inert gas. Hydrodynamic equations are used to describe the motion of the inert gas and the electron, ions, and neutrals of the electrode material. The processes of photoionization, radiative recombination, ionization by electron impact, and three-body recombination are included in the equations. It is found that sound waves become unstable when the drift velocity of the electrons exceeds a critical velocity which is of the order of the velocity of sound. (auth)

**28845** THEORY OF ACOUSTICAL MOTION IN RAREFIED PLASMA. D. G. H. Frood (Royal Armament Research and Development Establishment, Kent, Eng.). p.107-14 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The Landau theory of plasma is extended to include acoustical motions first by considering the diffusive fluctuations of a system of non-interacting particles. This model is next extended by considering the particles to be electrons in a uniform positive background, and the effect of the long-range Coulomb interaction is shown to cancel the diffusive terms so that acoustical motion cannot exist. To recover acoustical motion, the conventional model is modified by replacing the uniform background by a set of mobile positive ions. For the electrical variables, the diffusive terms are again cancelled by others arising from the interaction, but besides the high frequency modes, the plasma can support acoustical oscillations. For long wavelengths and $T_e \gg T_i$, the phase velocity of these low frequency waves equals the sound speed calculated by regarding the plasma as a continuum, propagating weak compressional disturbances. (auth)

**28846** PRODUCTION OF ACOUSTIC WAVES BY RF BREAKDOWN IN LOW PRESSURE GASES. L. Goldstein, M. R. Roux, and J. A. Dayton, Jr. (Univ. of Illinois, Urbana). p.115-20 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Acoustic waves, traveling at approximately the speed of sound, are observed to propagate in a low pressure, partially ionized gas, following localized breakdown of the gas by a high power, pulsed microwave field. The gas is contained in a cylindrical glass tube which penetrates through the E plane of an S-band waveguide. Breakdown is caused

by a 1 $\mu$ sec pulse of up to 400 kw peak power at 3 kMc. Gases used are He, Ne, Xe, Ar, and $N_2$. The waves are shown to be both ordinary sound waves in the neutral gas and ionic oscillations in the plasma. The possibility of using waves produced in this way for plasma diagnostics is discussed. (auth)

**28847** MAGNETOACOUSTIC RESONANCE IN A PLASMA. Edgar Cantieni and Helmut Schneider (Université, Fribourg, Switzerland). p.125-7 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Standing magnetoacoustic waves are produced in a cylindrical argon plasma. The plasma, which is immersed in an axial magnetic field; is generated by a discharge current and is highly ionized. The wave is excited at the plasma boundary and the measurements of the resonance curves on the axis and the radial distribution of the wave field are found to be in quantitative agreement with a magnetohydrodynamic theory for partial ionization. The determination of the degree of ionization with magnetoacoustic resonance was used as a new diagnostic method. These measurements are compared with spectroscopically determined decay curves. (auth)

**28848** LOW-FREQUENCY WAVES ON PLASMA COLUMNS. F. W. Crawford and S. A. Self (Stanford Univ., Calif.). p.129-32 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Experimental observations were made of propagating and standing ion waves of the type predicted by Tonks and Langmuir. There is still doubt as to the boundary conditions operative at the tube walls. If a potential minimum is postulated, there should be a low-frequency cut off, whereas propagation down to zero frequency should be possible with a potential maximum boundary condition. Studies of standing waves are described. Measurements are discussed in which propagating waves are excited on the positive column of a mercury-vapor discharge, at a pressure of about 1 $\mu$ Hg, by means of a coil surrounding the tube. Under conditions of high external circuit impedance, photomultiplier measurements were made which indicate the presence of disturbances propagating below the cut-off frequency, calculated on the assumption of a potential minimum boundary condition. (auth)

**28849** TRANSITION FROM LANDAU DAMPING TO VISCOUS DAMPING OF ION ACOUSTIC WAVES. R. W. Motley and A. Y. Wong (Princeton Univ., N. J.). p.133-6 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans Les Gaz. Vol. III." Paris, SERMA, 1963.

Previous experimental work on the propagation of ion acoustic waves in highly-ionized cesium plasmas was extended to denser plasmas ($n \gtrsim 4 \times 10^{12}$ cm$^{-3}$). In these plasmas the ion-ion collision frequency should exceed the wave frequency (<60 kc/sec), so that the fluid equations, rather than the collisionless equations, should better describe the wave propagation. The waves are excited by a tungsten grid immersed in the plasma column and are detected by a similar grid. There is a slow drift of plasma between the grids which gives rise to an asymmetry in the two directions of propagation. The downstream phase velocity was found to decrease from $1.3 \times 10^5$ cm/sec to $1.0 \times 10^5$ cm/sec and the upstream velocity from $6.9 \times 10^5$ cm/sec to $0.3 \times 10^5$ cm/sec as $\omega\tau$ decreases from 40 to 0.15, where $\tau$ is (related to) the ion-ion collision time. For the forward wave the damping distance $\delta$ increases from 0.55 $\lambda$ to ~2.5$\lambda$ with decreasing $\omega\tau$. The damping distance for the backward wave is much shorter, and does not change significantly with $\omega\tau$. The results are compared with the predictions of the fluid equations. (auth)

**28850** PROPAGATION OF LONGITUDINAL WAVES IN A PLASMA. Helmut Schneider and Edgar Cantieni (Université, Fribourg, Switzerland). p.137-9 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Phase velocity and damping constant for longitudinal waves without boundary are given as derived from a 3-component linear magnetohydrodynamic theory. These results are applied to the case of a partially ionized argon plasma in which the propagation of this mode is studied experimentally. It is pointed out that the velocity gives the temperature of the plasma when the magnetic field $B_0 = 0$ and the velocity at $B_0 \to \infty$ is a function of the degree of ionization. Experimental results demonstrate the entrainment of neutrals in the oscillation and are in agreement with theory. (auth)

**28851** EXCITATION OF LOW FREQUENCY OSCILLATIONS IN CYLINDRICAL PLASMAS. Masao Sumi (Electrical Communication Lab., Tokyo). p.141-3 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Low frequency oscillations excited by the interaction of a cylindrical plasma with an electron beam are investigated. By use of macroscopic equations, dispersion relations are derived for longitudinal space charge waves and for nearly neutralized sound waves. It is shown that the dispersion relation can be reduced to a form similar to that for the one-dimensional case. Characteristics of excited waves are easily discussed and compared with some experimental results. (auth)

**28852** VERIFICATION OF THE MACROSCOPIC THEORY OF THE PROPAGATION OF CIRCULARLY POLARIZED WAVES IN A PLASMA—DIAGNOSTIC APPLICATIONS. T. Consoli, G. Ichtchenko, D. Lepechinsky, F. Parlange, and M. Weill, (CEN, Saclay, France). p.145-8 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

Qualitative experimental studies demonstrated certain effects of the propagation of circular waves in a plasma, in particular the Faraday, Doppler, and Čerenkov effects. It is shown that, at the frequencies 1200 MHz, 16,000 MHz, and 35,000 MHz, using powers (from several milliwatts to 120 kw) either in a continuous or pulsed plasma, and with the static magnetic field employed (0 to 14 kgauss), a large domain can be explored. The static field is measured by magnetic probe; the temperature, by lines profiles; and the electronic density and absorption, by U.H.F. (auth)

**28853** GUIDED PROPAGATION ALONG A MAGNETIC FIELD OF MILLIMETER WAVES—PHYSICS—DESCRIPTION OF A UHF METHOD. T. Consoli, G. Gormezano, G. Ichtchenko, and M. Weill (CEN, Saclay, France). p.149-52 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

A remarkable property of the propagation along a magnetic field of a right circularly polarized wave is that the energy is guided by the field. This property is accentuated in particular for the whistler mode ($\omega_p \gg \omega_{hf}$, $\omega_{ce} > \omega_{hf}$). A cone of propagation can be defined for the Poynting vector. The experimental results presented demonstrate this property for a wave of a frequency of

35 kMcs. After a theoretical study of the guiding effect, the results obtained are discussed and the acceleration of the plasma due to the anisotropy of the pressure tensor is calculated. (auth)

**28854** THE PROPAGATION OF SLOW ELECTROMAGNETIC WAVES IN METAL CONTAINED LOW-PRESSURE PLASMA. U. Bauder (Technische Hochschule, Munich). p.153-9 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In German)

Propagation of slow electromagnetic waves in plasma wave guides and plasma cables was investigated. A low pressure gas discharge is maintained in a metal tube. The conditions can be chosen by control of the potential difference between plasma and metal wall. The observed frequency dependence of the phase velocity and absorption is in good agreement with theoretical prediction, particularly with regard to the upper cut-off frequency of the propagation range. The electron concentration of the plasma was measured as a function of the discharge current by means of Langmuir probes. Alternately the electron concentration may be determined from the upper cut-off frequency of the slow waves. Both methods lead to the same results. (auth)

**28855** THE CAUSE OF EXPERIMENTAL OBSERVATION OF ANOMALOUS DISPERSION BY THE PROPAGATION OF SLOW ELECTROMAGNETIC WAVES ON PLASMA CABLES. H.-G. Stablein (Technische Hochschule, Munich). p.161-6 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In German)

The theory of the propagation of slow electromagnetic waves in plasma cables is improved by consideration of the radial inhomogeneity of the plasma column. An approximation method is used to determine the frequency dependence of the phase velocity. It is found that anomalous dispersion observed is caused by the radial plasma inhomogeneity, and that information on the radial plasma density distribution is obtainable from slow wave measurements. Finally it is proved that anomalous dispersion cannot be attributed to the influence of a glass tube in a plasma cable that contains a homogeneous plasma column. (auth)

**28856** MICROWAVE CAVITY MEASUREMENT OF THE FARADAY EFFECT IN A MAGNETOPLASMA. Maurice T. Raiford and Frederic R. Crownfield, Jr. (Coll. of William and Mary, Williamsburg, Va.). p.167-70 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The coupling of the orthogonal, linearly polarized, $TE_{111}$ modes of a right cylindrical cavity due to the Faraday effect were observed in a coaxially located neon glow discharge. Measurements as a function of applied magnetic field are interpreted in terms of a simple theory to yield an effective electron collision frequency. The values of the collision frequency obtained in this way are greater than predicted from the momentum-transfer collision cross section. Some data showed anomalies near harmonics of electron cyclotron resonance, but these data were not reproducible. (auth)

**28857** MEASUREMENTS OF COLLISIONLESS DAMPING OF ELECTROSTATIC PLASMA WAVES. J. L. Hirshfield and R. N. Dennis, Jr. (Yale Univ., New Haven). p.171-7 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Measurements of the energy exchange between an electron stream and a periodic structure are described. The experimental conditions are such that steady-state longitudinal oscillations on the stream occur with both frequency and wave number as substantially real quantities. The electron stream has a thermal spread which can be varied by application of a random accelerating potential of adjustable rms value. According to theory, the dependence of the energy exchange upon frequency follows the velocity-space gradient of the electron distribution function; for comparison, this latter quantity was measured directly. Since the velocity-space gradient determines the Landau damping of a freely oscillating disturbance in the initial-value problem, the measurement described here may be considered as an indirect observation of this damping mechanism. (auth)

**28858** INCOHERENT SCATTERING OF RADIATION BY PLASMAS. D. F. Dubois (Hughes Research Lab., Malibu, Calif.) and V. Gilinsky. p.179-83 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Previous calculations on the incoherent scattering of radio waves from a plasma are extended to include the effects of close collisions. The plasma line is found to be significantly broadened by collisions. For most practical applications (e.g., ionosphere scattering) the low frequency mode is not changed very much. However, in a highly collision dominated situation, when the frequency of the acoustic mode is well below the ion-ion and electron-electron collision frequencies, the low frequency mode is significantly sharpened. A quantum-mechanical diagrammatic method is used, permitting a clear physical picture of the processes occurring in the plasma to be given. (auth)

**28859** NON LINEAR EFFECTS IN A PLASMA. Michael S. Macrakis (Massachusetts Inst. of Tech., Cambridge). p.185-8 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Effects of nonlinearities on the dispersion and attenuation of longitudinal waves in a plasma in equilibrium are presented. The hydrodynamic equations are used, and it is shown that to a first approximation nonlinearities affect only the dispersion equation. The problem is described in terms of a scattering process in which a density wave is scattered incoherently from the density fluctuations of the plasma in equilibrium. As a result of the scattering, there is a correction of the longitudinal dielectric coefficient which affects the dispersion law in the plasma. (auth)

**28860** LIGHT MIXING IN A PLASMA. Wilhem H. Hegel (Institut für Plasmaphysik, Garching, Ger.). p.189-90 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The theory of light scattering in a plasma is extended by including an external electric field (e.g., the field of a laser beam). The problem is treated by means of the Vlassov equation. It is shown that density fluctuations with the frequency and wave number of the external electric field arise in the presence of a homogeneous magnetic field of proper direction. If the light of a second beam is scattered by these fluctuations, light mixing occurs, i.e., the frequency of the scattered light is the sum or the difference of the frequencies of the two beams. In the framework of this theory, the effect occurs only if the two beams are parallel (sum frequency) or antiparallel (difference frequency). Numerical calculations show that the effect should be detectable in a high density plasma if laser beams are used. (auth)

**28861** ELECTROSTATIC STABILITY OF PLASMAS. Heinz Volk (Institut für Plasmaphysik, Garching, Ger.). p.191-6 of "VI$^{e}$ Conférence Internationale sur les Phé-

nomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The analogue of Ljapunovs stability theory for the Vlasov equation was formulated by Fowler. It was used for the investigation of electrostatic stability of inhomogeneous plasma configurations with selfconsistent electric field in an external electromagnetic field. This method is extended to equilibrium configurations with both selfconsistent magnetic and electric fields present. For a one dimensional equilibrium, the Vlasov equation exhibits certain symmetries that allow it to be written in the form $\partial f/\partial t + (A_1H + A_2)f = 0$. Here f is the perturbed distribution function. The operators $A_1$, $A_2$ are antisymmetric, the operator H symmetric, with respect to the scalar product (g,f). Similar to Fowler's case the form $(f,(A_2A_1^{+1} + H)f)$ is a constant of the motion. Therefore the configuration is stable if $A_2A_1^{-1} + H$ is a positive definite operator. This leads to a hermitean eigenvalue problem for the perturbed field. A first application of this theory to a one dimensional homogeneous plasma leads to the criterion of Jackson. This shows that, in this special case, the criterion is also necessary. (auth)

**28862** NEW ANALYTICAL METHOD FOR THE TREATMENT OF INSTABILITIES AND WAVES CROSSING IN SPACE. P. Rolland (CEN, Saclay, France). p.197-8 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

This new analytic method solves the problem of instabilities and growing waves. The criterion thus obtained is more general than that proposed by Sturrock in a purely kinematic treatment. A holomorphic condition imposed on the double Laplace transform eliminates at the same time the superabundant data and certain classes of solutions. The general criterion connects the nature—stable or instable, convective or not—of a perturbation and the form—damped or amplified—of the propagating wave to certain topologic properties of the dispersion equation involving the localization of the critical points and the behavior of the roots in the complex plane. (auth)

**28863** INTERACTION OF A DECELERATED ELECTRON BEAM OF DEPLETING NUMBER DENSITY WITH A PLASMA. S. V. Yadavalli (Stanford Research Inst., Menlo Park, Calif.). p.199-202 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The behavior of electrostatic instabilities when an electron beam (which is decelerated and whose density decreases with distance) penetrates a plasma is investigated. Both the infinite and finite beam cases are explored. Some comments are made on the effect of finite beam temperature on the growth rate of instabilities. A brief discussion regarding a hydromagnetic instability is appended. The utility of the above results to practical examples is indicated. (auth)

**28864** INTERACTION OF WAVES-GUIDED PARTICLES. J. C. Boulassier and G. Briffod (CEN, Saclay, France). p.203-5 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

When a plasma is influenced by an electric field $E_0$, the particles are accelerated producing a directed motion. If the field is weak $eE_0/m\nu < (kT/m)^{1/2}$ a stationary state may be obtained whose distribution function, a solution of the Boltzmann equation, if of the form $f^1_{(v)} = F_{(v)}\{1 + \vec{\alpha}.\vec{v}\}$ with $\vec{\alpha}_{(v)} \cdot \vec{v} \ll 1$. Propagation in this condition is a study of the influence of directed particles on the wave. The dispersion relation of waves propagating along a dc magnetic field Bo ($\vec{k} \parallel \vec{B}_0$) in a maxwellian plasma with collision is reviewed. The relation for the same waves when the fields $\vec{E}_0$ and $\vec{B}_0$ are parallel is established. (auth)

**28865** INTERACTION OF A BEAM OF PROTONS WITH PLASMA. Jacob Neufeld and Harvel Wright (Oak Ridge National Lab., Tenn.). p.207-8 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

An analysis is given of the behavior of a plasma-beam system in which a beam of protons each having mass $M_p$ interacts with a plasma comprised of electrons and singly charged ions each having mass $M_i$. A relation is formulated between the frequencies $\omega$ of excited waves and appropriate parameters characterizing the plasma-beam system. It is shown that in the low-frequency range there is a significant dependence between $\omega$ and $\alpha = M_i/M_p$, whereas in the high-frequency range $\omega$ is independent of $\alpha$. (auth)

**28866** PRODUCTION OF WAVES BY A PLASMA-BEAM SYSTEM IN A RESONANT CAVITY. M. M. Camus (Centre National d'Etudes des Télécommunications, France). p.223-32 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

Some theoretical results of investigation on wave propagation in plasma waveguides are recalled. Dispersion curves, obtained with a computer, are discussed in the case of cylindrical symmetric modes in two plasma-filled waveguides. A plasma was created in a microwave cavity filled with gas (argon) by an ionizing electron beam. Oscillations are expected at frequencies which are together cavity resonance frequencies and frequencies of interaction between electron beam and slow wave in the plasma waveguide. The main experimental results show that oscillations exist near $\omega_p$ when $\omega_p > \omega_c$ and near $\omega_c$ when $\omega_c > \omega_p$. (auth)

**28867** ELECTRON ENERGY STREAMING IN A COLLISIONLESS PLASMA. Paul W. Jameson and David R. Whitehouse (Massachusetts Inst. of Tech., Cambridge). p.237-42 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Energy perturbations were produced on the electrons at one end of a weakly ionized plasma column 200 cm long and 3 cm in diameter. The plasma was constrained by a longitudinal magnetic field and operated at a pressure around 0.1 $\mu$ Hg. The perturbations propagated down the column and were measured by a probe which was capacitively coupled to the plasma. Under various experimental conditions, there exist patterns of standing waves and forward and backward traveling waves. The results are important in the study of energy transfer and the techniques can be used to study time varying distribution functions. (auth)

**28868** INTERACTION OF TWO WAVES IN THE IONOSPHERE. APPLICATION TO LONG RANGE RADIO COMMUNICATIONS. B. Blachier, N'guyen van Tran, and E. Leiba (Cie Générale de Télégraphie Sans Fil Crobeville, Orsay, France). p.243-5 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The problem of the interaction between two waves of different frequencies, $f_1$ and $f_2$, is solved using the Boltzmann equation. Equations for currents at frequencies $f_1 - f_2$ are derived from macroscopic equations. Nonlinearities due to the variation of collision frequency are neglected. The

macroscopic treatment, taking into account all the nonlinearities of a homogeneous plasma, was undertaken. The results were applied to long-range radio communications in the two cases: (1) One frequency is equal to the plasma frequency, the other is 100 Mc. (2) One frequency is equal to the ionospheric cyclotron frequency, the other is 100 Mc. (D.E.B.)

**28869** PROPAGATION OF WAVES IN PLASMA SLABS AND COLUMNS. A. Gilardini (Selenia S.p.A., Rome). p.247-52 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Plasma slabs in magnetic fields confine and guide electromagnetic waves by successive internal reflections at the plasma boundaries. This approach allows the derivation of propagation characteristics in a straightforward manner from the propagation properties of slow waves in infinite uniform plasmas. This method is used to derive the characteristics both for a cold and for a warm plasma slab, when the magnetic field is in a plane perpendicular to the slab axial plane, but otherwise arbitrarily directed. An experimental apparatus for the detection of these waves in longitudinally magnetized columns and the experimental results are presented and discussed; the results are generally in agreement with the theory. (auth)

**28870** THE NONADIABATIC CHARACTER OF SLOW LONGITUDINAL WAVES IN PLASMA WITHOUT COLLISIONS WHERE $T_e = T_i$. LANDAU DAMPING OBTAINED BY BEGINNING WITH MOMENT EQUATIONS. D. Quemada. p.253-9 of "VI$^e$ Conférence Internationale sur les Phenomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

Slow waves for real $\omega^2$ and complex k are found from the linearized Vlasov equation, completing previous work for real $k^2$ and complex $\omega$. The dispersion curve shows a nondispersive branch, in fair agreement with experimental results on cesium plasma. For electron oscillation (ions at rest) the condition $Q_{||} = (\phi|| - NKT)v_g$ is obtained, where $Q_{||}$, $\phi_{||}$, and N are heat flow, pressure, and density perturbations and where $v_g = d\omega/dk$ is the group velocity of the wave. This condition closes the system of the three moment equations for electrons, and gives a differential equation for $\omega(k)$. The exact dispersion equation, including Landau damping, is found. (auth)

**28871** HARMONICS OF THE ELECTRON CYCLOTRON FREQUENCY IN A PIG-DISCHARGE. E. Canobbio and R. Croci (Institut für Plasmaphysik, Garching, Ger.). p.269-71 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

A possible mechanism is proposed for the emission of more than 40 harmonics of the electron cyclotron frequency observed in a PIG discharge. Quasi-electrostatic waves propagating nearly perpendicular to the magnetic lines should be radiated by superthermal electrons. The width of the lines and the absorption coefficient are given by the Landau damping. The transmission coefficient for the longitudinal waves is also calculated. (auth)

**28872** NARROW-BAND NOISE RESONANCES IN AFTERGLOW PLASMAS. C. C. Leiby, Jr. and W. D. McBee (Sperry Rand Research Center, Sudbury, Mass.). p.273-8 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The transient noise power emitted by afterglow plasmas (Ne, He, Ar, Xe, Ne–Ar, Xe–He, p = 0.6 to 18.5 torr) was observed using a narrow band (~1 mc) low noise ($T_{input} \approx$ 200°K) receiver whose center frequency was 5.5 kM. A fine structure of resonances was observed during the afterglow of all the gases investigated. Insertion loss for a 5.5 kM CW signal propagated through these plasmas evinced absorption resonances which corresponded in time with observed maxima in emitted noise power. The resonances were found to be dependent upon electron density and collision frequency as well as direction of polarization with respect to the plasma axis. This suggests that a particular noise frequency sees a quasi-black-body cavity with reflecting walls whose optical size changes as the plasma decays. (auth)

**28873** EMISSION AND ABSORPTION OF RADIATION IN THE NEIGHBORHOOD OF THE PLASMA FREQUENCY. Ludwig Oster (Yale Univ., New Haven). p.279-80 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

A consistent formulation of the problem of radiative transfer in dispersive media is presented in the form of a simplified version of a semiclassical transport theory for a photon gas. A general solution is obtained for the specific intensity both inside the plasma and in an adjoining vacuum. It is shown that the intensity of the escaping radiation is greatly reduced, as compared with the case of a nondispersive medium, if the plasma becomes optically thick in regions where the refractive index differs from unity. These results deviate significantly from previous treatments based on purely phenomenological arguments. As an example, the radio emission of a fully ionized gas in the neighborhood of the plasma frequency is computed for various profiles of the electron density. (auth)

**28874** EXPERIMENTS ON THE NEGATIVE RADIATION TEMPERATURE AT CYCLOTRON RESONANCE IN PLASMA. Kenji Mitani (Kyoto Univ.), Hiroshi Kubo, and Shigetoshi Tanaka. p.281-5 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The anomalous microwave radiation from a d-c discharge plasma in a magnetic field was observed. The intensity was extremely large compared with that of the black body and amounted to the power radiated from the plasma in the thermal equilibrium equivalent to $5.5 \times 10^6$ °K in Xe. This radiation occurred very sharply at the cyclotron resonance in Xe, Kr, and Ar plasmas, but not in Ne and He plasmas. The theoretical condition for a negative temperature at the cyclotron resonance in a weakly ionized gas was investigated. Then it was discussed whether this anomalous radiation could be interpreted as a phenomena of the negative radiation temperature. (auth)

**28875** NONTHERMAL LINE RADIATION FROM AN OPTICALLY THICK PLASMA. S. Cuperman, F. Engelmann, and J. Oxenius (Euratom-CEA, Fontenay-aux-Roses, France). p.287-8 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The steady-state radiation of a homogeneous and isothermal plasma sphere due to an optically thick spectral line is studied under the assumption that all other transitions of the considered atoms are optically thin. The equation of radiative transfer and the steady-state balances for the occupation numbers of the atomic levels are solved simultaneously. The line profile is approximated by a rectangular profile and by a Doppler profile, respectively. The power radiated from the sphere can be described in most cases of practical interest by a simple volume radia-

tion formula even for fairly large optical thicknesses. The spectral distribution of the intensity of a Doppler broadened, optically thick line is in some cases double humped, thus simulating self-absorption effect of a cold outer plasma layer. (auth)

**28876** THE CRITERIA FOR THE OPTICALLY THIN APPROXIMATION IN SPECTRAL LINE INTENSITIES. A. G. Hearn (Culham Lab., Abingdon, Berks, Eng.). p.289-91 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (CLM-P-24; CONF-75-7)

In the interpretation of many spectroscopic measurements of plasmas, it is assumed that the plasma is optically thin for the radiation concerned. Criteria for the validity of this assumption are developed for the intensities of Doppler broadened resonance lines using a model of the diffusion of resonance photons in frequency space. For a high electron density plasma where the excited level population is determined by collision processes and not radiative processes, the equation of transfer of radiation has a simple solution and the optical depth must be less than 0.3 if the total intensity of the line is to be proportional to the number of emitting atoms to within 10%. In a low electron density plasma where spontaneous transitions dominate electron de-excitation, the maximum optical depth can be much greater for a resonance line such as Lyman $\alpha$, where the resonance line is the only possible radiative transition. For a resonance line such as Lyman $\beta$, where there is a comparatively strong competing radiative transition, Balmer $\alpha$, for which the plasma is optically thin, the effect of optical depth is much more severe. (auth)

**28877** STARK BROADENING OF NONHYDROGEN LINES IN PLASMA. S. L. Mandelstam, M. A. Masing, I. I. Sobelman, and L. A. Vainshtein (Lebedev Inst. of Physics, Moscow). p.331-6 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

A short review of results obtained in the theoretical and experimental investigation of the problem of broadening of spectral lines with quadratic Stark effect in fully ionized plasma is given. Formulas for calculations of widths and shifts of spectral lines in one-perturbing-level and many-perturbing-levels approximations are presented. The measurements were carried out for more than 100 lines of ArII, HeI, NeII, KII, AlIII, SnIV, SiIII, SiIV. The comparison of calculated and experimental data shows that the theory satisfactorily describes the broadening of nonhydrogen lines. (auth)

**28878** SOFT X-RAY EMISSION FROM A MAGNETICALLY COMPRESSED PLASMA. H. Herold and G. Decker (Institut für Plasmaphysik, Garching, Ger.). p.341-6 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The time-resolved radial distribution of soft x-ray emission in a $\Theta$ pinch was investigated. The radial resolution was obtained by a row of channels viewing the discharge axially. Framing camera pictures were taken simultaneously. The measurements give for different trapped fields radial profiles of x-ray intensity. The electron temperature is determined under the assumption of pure bremsstrahlung using absorption foils. The maximum intensities of x rays and electron temperature—especially for antiparallel trapped fields—are observed at different radii during the development of the discharge. Breakup and axial motions of the plasma column are recorded by framing camera pictures. (auth)

**28879** SPECTROSCOPIC STUDY IN THE VACUUM-UV ON THE PLASMA OF A LOW-PRESSURE SPARK. F. J. Comes and H. G. Salzer (Universität, Bonn). p.353-7 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In German)

A highly ionized plasma was produced by discharging a capacity of 0.5 $\mu$e through a quartz capillary of 1.5 mm diameter. The stored energy was a maximum of 10 j. The discharge was self triggered and was fired with a repetition frequency of 50 cycles. The source and mechanism of the emitted continuous radiation were investigated. The radiation was equivalent to that of a black body at 15,000°K. The time resolution of the emitted radiation indicates the vaporization of the wall material, necessary for the production of continuous radiation. The measurements show that the intensity of the central parts of the lines is comparable with that of a black body. A comparison of the measured excitation and ionization temperatures clearly indicates that the plasma is not in thermodynamic equilibrium. (auth)

**28880** A SPECTROGRAPHIC ANALYSIS OF HYDROGEN AND AIR PLASMAS. Richard M. Head (Institut de Mécanique des Fluides, Marseille and Naval Postgraduate School, Monterey, Calif.). p.395-9 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

An electromagnetic shock tube, utilizing a 20 kv, 5000 j capacitor bank, is used to generate a strong, ionizing shock wave that travels at approximately 3 cm/$\mu$sec in hydrogen and at approximately 1 cm/$\mu$sec in air. The time-integrated emission spectra of the plasmas, obtained with the Coude spectrograph, are analyzed. Measurements of relative line intensities, line profiles and Doppler shifts are used to evaluate the plasma temperature, density, and velocity in various regions of the flow behind the ionizing shock wave. (auth)

**28881** MEASUREMENT OF LINE PROFILES AND THEIR RELATIVE INTENSITIES FOR THE DETERMINATION OF THE ELECTRON DENSITY AND TEMPERATURE OF HELIUM PLASMA PRODUCED IN A SHOCK TUBE. W. L. Bohn and P. Platz (Technische Hochschule, Aachen). p.407-13 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In French)

Experimental line profiles from an electromagnetically driven shock tube plasma are compared with theory for the lines He II 3203, He II 4686, and He I 3889. The perturbations in the blue wing of the line He II 3203 are discussed. The resulting values of electron density agree within 30%. The structure of the plasma derived from spectroscopic measurements is in good agreement with streak-camera photographs. (auth)

**28882** ON THE GENERALIZATION OF THE HOLTSMARK THEORY TAKING ACCOUNT OF THE THERMAL MOTION OF THE "BROADENING" IONS. V. I. Kogan (Academy of Sciences, USSR). p.415-17 of "VI$^e$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The thermal motion of perturbing ions in a plasma causes a deviation of the broadened atomic spectral line shape from its static shape as predicted by the Holtsmark theory. Calculations of this effect were strongly different from one another. The cause of this discrepancy is revealed. Wimmel' results are shown to be erroneous. In particular, they disagree in the limit of the line wing with

the binary result of Holstein and unrealistically limit the domain of applicability of the Holtsmark theory. (auth)

**28883** TRANSFER OF RESONANCE IMPURITY RADIATION IN A RAREFIED PLASMA. V. A. Abramov and V. I. Kogan (Academy of Sciences, USSR). p.419-22 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

The radiation of impurities with $Z \gg 1$ plays an important part in the energy balance of hot plasmas. Post gave estimates of radiative losses due to line radiation of impurities taking into account the reabsorption of this radiation within the plasma. The problem is studied in detail, and existing discrepancies cleared up. Some of Post's final formulas are found to be erroneous. (auth)

**28884** UNEQUAL DENSITY PROPERTIES OF ARGON–CESIUM PLASMA. V. A. Abramov and Yu. A. Tarassov (Academy of Sciences, USSR). p.423-7 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963. (In German)

A computation is carried out of the conductivity and the strength of the electric field necessary for heating electrons in an argon-cesium plasma to 3000 to 4000°K. Elastic and inelastic energy losses are considered. The total energy losses and the conductivity are presented as functions of concentration. The electric field gradient is given in terms of the electron temperature. (M.J.T.)

**28885** ON THE WIDTH OF SPECTRAL ATOMS LINE IN PLASMA. L. P. Kudrin (Academy of Sciences, USSR). p.429-31 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

Green's functions and diagram techniques are used for the correct calculation of the probabilities of radiative atomic transitions in plasma, taking into account the correlation of charged particles. In the case when the distance between atomic levels is small compared to kT, the impact width formula, in which the expression in the logarithm is determined precisely and depends on Langmuir frequency may be obtained. (auth)

**28886** THE NEW METHODS OF PLASMA DIAGNOSTICS BY THE USE OF SPECTROSCOPIC DATA. L. P. Kudrin and G. V. Sholin (Academy of Sciences, USSR). p.433-7 of "VI$^{e}$ Conférence Internationale sur les Phénomènes d'Ionisation dans les Gaz. Vol. III." Paris, SERMA, 1963.

A method of measurement of charged particle concentration in dense plasma is based on comparison of experimental and calculated spectral line profiles. Asymmetry of the $H_\beta$ and $H_\delta$ lines and shift of the $H_\gamma$ and $He_{II}$ lines at 4686 Å was observed. The theory of spectral broadening does not account for these anomalies. It is shown that the anomalies are simple functions of the charged particle density. Results for calculations of the $H_\beta$-line form and of the maximum $He_{II}$ shift are given. The shift increased linearly with density, in good agreement with experiment. The calculated shift depends slightly on the ion distribution and the gamma impact. (M.J.T.)

**28887** A MICROWAVE METHOD OF MEASURING PLASMA VELOCITY. James W. Cunningham (ARO, Inc., Arnold Air Force Station, Tenn.) and John B. Dicks. 38p. (CONF-535-1)

From 3rd Hypervelocity Techniques Symposium, Denver, Mar. 1964.

A method of measuring plasma velocity is described which depends on observing the rate at which electron density fluctuations travel downstream. Two variations of the method are possible. First, it is possible to time the passage of naturally occurring electron density fluctuations between two stations at which microwave energy is transmitted through the plasma. Second, it is possible to produce an artificial disturbance in electron density and to time its passage to a single microwave transmission path a short distance downstream. Correlation plots are shown for several spacings between microwave channels using natural fluctuations. Waveforms obtained at varying distances downstream from a spark discharge are shown, and the velocity measured is compared to an aerodynamically measured velocity. (auth)

**28888** INTERACTION OF MICROWAVE RADIATION WITH A NON-UNIFORM PLASMA SHEATH ADJACENT TO A CONDUCTING WALL. M. M. Klein (General Electric Co., [Philadelphia]). 36p. (CONF-471-10)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

The interaction of microwave radiation with a non-uniform plasma sheath terminated by a conducting wall was obtained both by numerical solution and by the WKB method. Two electron density profiles, one of exponential form and the other parabolic, were chosen for the investigation. For the exponential profile the reflection coefficient decreases from unity at low electron densities to an asymptotic value at high electron densities; this limiting value is identical with the corresponding result for the infinite plasma. For the parabolic profile, however, as the electron density increases the reflection coefficient decreases from unity to a minimum and then increases to unity as the electron density becomes large. The results show, in addition, that the distribution of absorbed flux is much more markedly affected by an increase in maximum electron density for the case of the parabolic profile than it is for the exponential case. Because of the presence of a conducting wall, use of the connection formulas of the WKB method lead to inaccuracies not incurred in the case of an infinite plasma. The calculations by the WKB method have therefore been confined to the region of wavelengths and maximum electron densities where these errors are estimated to be small. (auth)

**28889** OBSERVATIONS OF GROWING WAVES IN A BEAM-PLASMA INTERACTION. John R. Apel and Albert M. Stone (Johns Hopkins Univ., Silver Spring, Md.). 25p. (CONF-471-12)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

Observations were made on the spatial and temporal behavior of space-charge oscillations excited in a warm electron-cold ion plasma by a counterstreaming electron beam. The hydrogen plasma generated by a P.I.G. source has a density of $8 \times 10^{10}$ cm$^{-3}$ and an electron temperature of 12 ev; the electron beam has a number density of $8 \times 10^{8}$ cm$^{-3}$ and streaming velocities up to $2.5 \times 10^{9}$ cm/sec. Collimation is provided by a guide magnetic field of 240 gauss. Oscillations at 800 Mc were observed with a probe system; these grow in time with a rate which is about 25 percent of the value derived from linearized theory. No spatial growth of the waves was detected, nor is any expected since the system ought to be equivalent to an oscillator, not an amplifier. (auth)

**28890** BEAM-PLASMA MODES IN CYLINDRICAL GEOMETRY. Ernest P. Gray (Johns Hopkins Univ., Silver Spring, Md.). 13p. (CONF-471-13)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

In order to attain a more complete physical understanding of the solutions of the dispersion relation for a general beam-plasma system in a bounded geometry, various limiting cases were investigated. The effect of the three-dimensionality of the beam is investigated by considering the interaction of a cylindrical beam with an infinite plasma in the limit of large beam radius. The question of whether or not all modes of the cylindrical system have as their limit one of modes of the limiting one-dimensional system is considered. For the simplified case with both beam and plasma cold and the ions considered as stationary, the result is that each of the two well-known modes of the one-dimensional system (one spatially growing, the other damped for frequencies below the plasma frequency) splits into infinitely many modes when the beam radius is made finite, and, except for two new free-space modes with $k = \pm\omega/c$, no other modes appear. The transport of energy is investigated in detail from Poynting's theorem. Numerical results are presented and discussed. (auth)

**28891** EXPERIMENTAL DETERMINATION OF THE ADIABATIC REGION IN A CUSPED GEOMETRY. Claude S. Leffel (Johns Hopkins Univ., Silver Spring, Md.). 14p. (CONF-471-14)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

An attempt is made to determine the boundaries of the region in a cusped magnetic field for which the magnetic moment is, to an extent which can be specified, an adiabatic invariant. Energetic electrons are injected from a source located within the cusp. If confined within an adiabatic region, they form a sheet concentric with the axis of the cusp where they remain until scattered into a loss cone. Electrons are detected after they have escaped the cusped field by an electron multiplier. Adiabaticity is established by the existence of the concentric sheet of electrons which is detected by the insertion of a scatterer located along lines of force intercepted by the detector. Computations show that for a field defined by the lines of force $\psi = r^2 z\ cm^3$, the critical line of force separating the adiabatic from the non-adiabatic region is given by $\psi_c = (a\ m\ v_\theta/eB_0)^3$ where $B_0$ is the minimum value of the field along $\psi_c$ and a = 8.8. Gray and Miller calculated the value a = 5.5; this experiment yields $a = 6.2 \pm 0.5$. (auth)

**28892** IMPLOSION MEASUREMENTS IN A SMALL FAST THETA' PINCH. Robert Turner (Johns Hopkins Univ., Silver Spring, Md.). 12p. (CONF-471-15)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

The implosion characteristics of a theta pinch were studied with an image converter camera and double magnetic probe for the gases Ar, He, $H_2$, and $D_2$ and for pressures in the ragne of .02 to 2.0 torr and several values of peak magnetic fields. The pinch is produced by two closely spaced single turn coils. Each coil has its own 2 microfarad, 50 kilovolt capacitor source and main and crowbar switches. This coil arrangement was chosen to provide various magnetic field configurations for future studies of the theta pinch as a plasma gun. A maximum magnetic field of 50 kilogauss ringing at a frequency of 410 kilocycles is produced in a 3 centermeter diameter tube. The compression phase is being studied to determine a suitable time to attempt transfer of the plasma out of the mirror region. In the geometry with a preionizer, the plasma is stable during the implosion phase until it reaches minimum radius. For magnetic fields greater than about 15 kilogauss, the plasma appears to break up at minimum radius and hit the containing wall. (auth)

**28893** MEASUREMENT OF ION ENERGIES IN THETA PINCH. L. M. Goldman, R. W. Kilb, and H. C. Pollock (General Electric Research Lab., Schenectady, N. Y.). 25p. (CONF-471-4; 64-RL-(3600 E)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

The energy of the deuterons in a $\theta$-pinch device was determined by comparing the rate of production of neutrons and 14.7-Mev protons when a plasma of D and $He^3$ is compressed. The different energy dependence of the fusion cross sections for $D + D \rightarrow He^3 + n$ and $D + He^3 \rightarrow He^4 + p$ allows a determination of the deuteron energy if the velocity distribution function is properly chosen. Using a monoenergetic velocity distribution, the energy of the deuterons undergoing fusion is found to be in the range of 10 kev for the conditions of the experiment. (auth)

**28894** INTERACTION OF COLLISIONLESS PLASMA STREAMS WITH TRANSVERSE MAGNETIC FIELD. J. M. Sellen, Jr. and W. Bernstein (TRW Space Technology Labs., Redondo Beach, Calif.). 22p. (CONF-471-5)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

A collisionless field-free synthesized $Cs^+$ plasma stream is impacted on the transverse magnetic field of a C-electromagnet. The configuration of a narrow beam is maintained as stream widths (~4 cm) are small compared to the ion cyclotron radius. The interaction is observed to be unstable when the plasma penetrates or traverses a magnetic field in excess of ~5 gauss. The instability is manifested by the appearance of both high (10-100 Mc) and low (100 kc) oscillations. It is believed that the instability arises from contra-streaming electron currents generated by a peaked potential structure in the boundary gradient region. (auth)

**28895** INTERACTION OF RESONANT PLASMA OSCILLATIONS. R. A. Stern (Bell Telephone Labs., Inc., [Whippany, N. J.]). 21p. (CONF-471-9)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

Resonances in the scattering cross section of small-diameter plasma columns on which microwaves are normally incident were attributed to the excitation of linear electron-plasma oscillations. An interaction was observed between two low-power microwave signals of different frequencies, which occurs when the signals are simultaneously incident on a plasma column, and the signal and plasma-electron frequencies are chosen to excite two different electron-plasma oscillation modes. The interaction is characterized by a very sharp rise time (less than 0.1 $\mu$s) and by a change from attenuation to enhancement in scattering cross section as the ratio of plasma to microwave frequencies is varied about the resonant value. Properties and some nonlinear models for the interaction are discussed. (auth)

**28896** THE GENERATION OF DENSE HIGH TEMPERATURE PLASMAS BY MEANS OF COHERENT OPTICAL RADIATION. A. G. Engelhardt (Westinghouse Research Labs., Pittsburgh). 39p. (CONF-471-7)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

The previous calculations of Basov and Krokhin in determining the laser properties necessary for the generation of dense unconfined high-temperature plasmas for temperatures up to 10 kev are extended. The physical situation considered is that of an initially solid or liquid particle in the focus of a pulsed laser beam of wavelength 7000 Å. At the end of the pulse the particle is at a final temperature T and has expanded to a radius which is

equated with the mean free path for bremsstrahlung at the laser frequency. It is determined that the energy lost in bremsstrahlung and recombination radiation is substantially less than that required for enthalpic heating. In the case of a 50% deuterium and 50% tritium plasma for a particle mass of $10^{-9}$, $3 \times 10^{-9}$, $4.4 \times 10^{-9}$, and $2.7 \times 10^{-9}$ kg and T = 0.2, 0.5, 1.0, and 5.0 kev respectively, one requires pulse lengths of 3.0, 2.4, 1.6, and 0.41 nanoseconds and total laser energies of 46, 350, 1000, and 3000 joules to produce plasma of density $2.3 \times 10^{26}$, $3.5 \times 10^{26}$, $5.6 \times 10^{26}$, and $2.3 \times 10^{27}$ $m^{-3}$. Respectively $2.6 \times 10^{3}$, $4.0 \times 10^{7}$, $8.0 \times 10^{9}$, and $7.4 \times 10^{13}$ neutrons would be produced per pulse. Optimistic estimates indicate that the energy produced in thermonuclear reactions is less than the laser energy input. Magnetic confinement might increase the thermonuclear energy output, but unfortunately the fields required are not now technically feasible. (auth)

**28897** WIDE RANGE MICROWAVE SPECTROSCOPY OF NOISE RADIATION FROM MAGNETOPLASMAS. C. D. Lustig, W. D. McBee, and A. Kalisky (Sperry Rand Research Center, Sudbury, Mass.). 10p. (CONF-471-8)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

A microwave spectrometer capable of measuring the noise power radiated by a plasma in a magnetic field as a continuous function of frequency from 2-4 Bcps was constructed. Within this bandwidth, noise resonances at the 5th to 8th harmonics of the electron cyclotron frequency have been displayed, while all discharge parameters, including the magnetic field, were kept constant. (auth)

**28898** SCALING LAWS FOR HIGH DENSITY PLASMAS. C. E. Muehe (Massachusetts Inst. of Tech., Lexington). 12p. (CONF-471-6)

From American Physical Society 5th Annual Meeting, San Diego, Calif., Nov. 1963.

The classical similarity laws are rederived in a way which quite clearly points out their limitations. They fail to apply when the charge density is sufficiently large that collisions between charged particles, gas heating, and other affects start to determine the character of the discharge. Fortunately, in this region of high charge density, Poisson's law need not be used to scale the charge density, so that the density of each species of particles can be normalized to the gas density at a given point in the discharge, providing all collisions are binary. It is shown that the high-current limit and the wavelength-to-diameter ratio of traveling striations in the argon positive column are functions of pI (pressure times current) in agreement with the high density scaling laws. The electric field to pressure ratio is also a function of pI. Exceptions to the new scaling laws are discussed in the case of spontaneous emission, three-body collisions, internally-generated magnetic fields, and gravitational effects. (auth)

## Shielding

*Refer also to abstract 28907.*

**28899** ALPHA-PARTICLE PENETRATION DEPTH IN CRYSTALLINE ANTHRACENE. G. E. Heppell (Univ. of California, Los Angeles). J. Chem. Phys., 41: 577-8 (July 15, 1964).

Anthracene crystals of 20 to 60 $\mu$ thickness were subjected to $^{210}$Po alpha particles (5.3 Mev) to determine the penetration depth. The scintillation efficiency was used to determine the penetration depth since the number of photons emitted from the crystal is a function of the particle path length. The calculated and experimental results were in good agreement. (C.E.S.)

**28900** AN EXPERIMENTAL EVALUATION OF REACTOR CONTAINMENT SHIELDING. H. S. Bloomfield and A. Foderaro (Pennsylvania State Univ., University Park). J. Nucl. Energy Pt. A & B, 18: 169-72(Apr. 1964).

Skyshine dose rates were measured over a wide range of distances from shadow-shielded containment vessels (scale models in water) filled with $^{128}$I and $^{56}$Mn gamma sources. The dose rate measurements were extrapolated to distances in air and were then compared with calculations by Geller and Epstein to assess the errors introduced into the calculations by their assumptions. (D.C.W.)

**28901** $Sr^{90}(+Y^{90})$ BETA RADIATION SELF-ABSORPTION IN PREPARATIONS OF SURFACE DENSITIES UP TO 28 mg/cm$^2$ MEASURED WITH 4$\pi$-COUNTER. Josef Klumpar and Miroslava Majerova (Inst. of Radiological Dosimetry, Czechoslovak Academy of Sciences, Prague). Jaderna Energie, 10: 168-71(May 1964). (In Czech)

Measurements of preparations having surface densities in the range 0.947 to 28.5 mg/cm$^2$ and made from strontium sulfate with known $^{90}$Sr[$^{90}$Y] content proved specific activity measurements of powder preparations by the extrapolation method on a 4-$\pi$ counter are possible. The possibility of applying the theoretical formula for calculations of the absorption in an irradiated layer was checked. (auth)

**28902** THE USE OF LEAD AS A SHIELDING MATERIAL AT TRAWSFYNYDD NUCLEAR POWER STATION. Metallurgia, 69: 209-12(May 1964).

The use of Pb as a shielding material for four fueling machines at Trawsfynydd nuclear power station is discussed. The project demonstrates the usefulness and versatility of Pb and Densithene (Pb-loaded polythene) for the shielding requirements of the nuclear power program. In addition to the fueling machines, ancillary equipment shielded with Pb on the station includes hoist stands, shield plugs, shield gates, hose disposal stand with internal guillotine, transport flasks, spectrometer castle, isotope containers and other standard shielding products. Ion chamber mechanisms have used Densithene. The total weight of Pb used for shielding purposes on the station is of the order of 800 tons. (P.C.H.)

**28903** THE DETERMINATION OF SPACE SHIELDING EFFECTIVENESS BY A GAMMA TRANSMISSION METHOD. A. D. Krumbein and R. Schamberger (United Nuclear Corp., White Plains, N. Y.). Trans. Am. Nucl. Soc., 7: 15-16(June 1964).

**28904** ESTIMATES OF THE SOLAR PROTON RADIATION HAZARD FOR MANNED SPACECRAFT BASED ON A MODEL ENVIRONMENT CONSTRUCTED FOR THE LAST SOLAR ACTIVE YEAR'S (1956-1961). Charles H. Warneke (McDonnell Aircraft, St. Louis). Trans. Am. Nucl. Soc., 7: 17-18(June 1964).

**28905** BASIC SYNTHESIS THEORY FOR PROTON SHIELDS SUBJECT TO AN ENERGY-CUT-OFF CONSTRAINT. F. R. Nakache, A. D. Krumbein, and P. S. Mittelman (United Nuclear Corp., White Plains, N. Y.). Trans. Am. Nucl. Soc., 7: 18-19(June 1964).

**28906** SYNTHESIS OF MINIMUM-WEIGHT SPHERICAL PROTON SHIELDS SUBJECT TO DOSE CONSTRAINTS. J. Celnik and F. R. Nakache (United Nuclear Corp., White Plains, N. Y.). Trans. Am. Nucl. Soc., 7: 19(June 1964).

**28907** A GENERAL GEOMETRY SHIELDING CODE FOR SPACE PROTONS. Richard Madey, David Levine,

Frank E. Schwamb, and Florian M. Sisavic (Republic Aviation Corp., Farmingdale, N. Y.). Trans. Am. Nucl. Soc., 7: 19-20(June 1964).

**28908** COMPARISONS OF MEASURED AND CALCULATED NEUTRON FLUXES IN LAMINATED IRON AND HEAVY WATER. E. Aalto (AB Atomenergi, Studsvek, Tystberga, Sweden). Trans. Am. Nucl. Soc., 7: 39-40 (June 1964).

**28909** FORWARD AND BACK SCATTERING OF COBALT-60 RADIATION BY PARALLEL STEEL SLABS. R. L. MacNeil and M. J. Barrett (Technical Operations Research, Aberdeen Proving Ground, Md.). Trans. Am. Nucl. Soc., 7: 38(June 1964).

**28910** REFLECTION OF THERMAL NEUTRONS AND NEUTRON-CAPTURE GAMMA RAYS FROM CONCRETE. M. B. Wells (Radiation Research Associates, Inc., Fort Worth, Tex.). Trans. Am. Nucl. Soc., 7: 41(June 1964).

**28911** A LAST-COLLISION APPROACH TO CALCULATING THE ANGULAR DISTRIBUTION OF FAST NEUTRONS PENETRATING A SHIELD. R. L. French (Radiation Research Associates, Inc., Fort Worth, Tex.). Trans. Am. Nucl. Soc., 7: 41-2(June 1964).

**28912** EXPERIMENTAL DETERMINATION OF NEUTRON ATTENUATION IN ZIRCONIUM HYDRIDE. W. E. Selph (Chance Vought Aircraft, Inc., Dallas). Trans. Am. Nucl. Soc., 7: 42-3(June 1964).

**28913** ATTENUATION OF FAST NEUTRONS BY LITHIUM HYDRIDE. S. G. Wogulis and A. W. Thiele (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 43-4(June 1964).

**28914** A SIMPLIFIED MONTE CARLO APPROACH TO DEEP-PENETRATION PROBLEMS. Leo Levitt (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 44(June 1964).

# REACTOR TECHNOLOGY

## General

*Refer also to abstracts 27654, 27841, and 27842.*

**28915** (AEEW-R-361) THE STATUS OF THEORETICAL METHODS FOR REACTOR SHIELD DESIGN. J. Butler (United Kingdom Atomic Energy Authority. Reactor Group. Atomic Energy Establishment, Winfrith, Dorset, England). Mar. 1964. 52p.

The current techniques employed for the design of shields of power reactors in Britain are reviewed. The general approach is based on the new RASH E removal age-diffusion code in conjunction with line of sight corrections for streaming. The validity of this technique was established by comparison with theoretical spectra computed by transport codes and with integral experimental data from a wide range of bulk shield and duct configurations in the LIDO Panel facilities at Harwell. As an example of its application, the theoretical predictions are compared with measurements made during the commissioning and operation of the gas-cooled Magnox reactors at Calder Hall and Chapelcross. (auth)

**28916** (DPST-64-83-4) USAEC-AECL COOPERATIVE PROGRAM MONTHLY PROGRESS REPORT, APRIL 1964. J. E. Beach, comp. (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). May 15, 1964. Contract AT(07-2)-1. 10p.

A series of experiments simulating burned-up fuel from the CANDU and similar heavy-water power reactors were initiated by fuel assembly fabrication. The CANDU fuel irradiation test in HWCTR is reported as in progress. Heat transfer burnout in heavy-water-moderated, boiling water reactors with closely spaced fuel rods was studied; laminated ribs were found to be effective spacers. The research on hydride orientation and mechanical properties of thin-walled Zircaloy tubing was delayed because of cracking of Zircaloy-2 guide tubes for the HWCTR safety rods. The evaluation of sieve tray capacity in an idle unit at the Savannah River Plant is partially completed. (R.E.U.)

**28917** (HW-79280) RESEARCH AND DEVELOPMENT PROGRAMS EXECUTED FOR THE DIVISION OF REACTOR DEVELOPMENT QUARTERLY PROGRESS REPORT, JULY, AUGUST, SEPTEMBER 1963. M. M. Hendrickson and J. K. Green, eds. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Oct. 1963. Contract AT(45-1)-1350. 153p.

Separate abstracts were prepared for the 9 sections presented. (R.E.U.)

*For abstracts of individual papers see: 27278, 27750, 27856, 28043, 28087, 28918, 29001, 29044, and 29045.*

**28918** (HW-79280(p.3.1-21)) ANALYTICAL STUDIES AND ADVANCED CONCEPTS. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Spike Plutonium (Seed-Blanket) Systems Study. Early results from the seed-blanket systems study show blanket exposures of 60,000 Mwd/ton for natural uranium with maximum to minimum power ratios of about 2. Impact of High $^{244}Cm$ and $^{238}Pu$ Prices. High market prices for $^{244}Cm$ and $^{238}Pu$ would influence reactor and fuel design and operation to emphasize production of these isotopes in preference to heat and neutrons. Plutonium Recycle and Uranium conservation. Uranium conservation indexes are being measured against mass balances of uranium, thorium, and bred fuels. Fast Supercritical Pressure Power Reactor (FSPPR). Nuclear design of the FSPPR was completed. Large Fast Reactor Core Design. (auth)

**28919** (NAA-SR-9090) QUARTERLY TECHNICAL PROGRESS REPORT. AEC UNCLASSIFIED PROGRAMS, JULY–SEPTEMBER 1963. (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Nov. 16, 1963. Contract AT-11-1-GEN-16. 255p.

The development and research activities related to reactors and the field of radiation chemistry and physics are summarized. Information is included on: Sodium Reactor Experiment, liquid-metal-cooled reactors, Hallam Power Reactor, organic-cooled reactors, Organic Moderated Reactor Experiment, Piqua Power Reactor, reactor safety, fuel element development and testing, sodium chemistry, uranium carbide development, concrete properties, fission product retention by reactor coolants, uranium oxide studies, nuclear properties of reactor materials, radiation chemistry, metallurgical studies, crystal analysis, neutron studies, thermodynamic properties of gases and liquids, reactor materials development, and radiation effects on chemicals and metals. (N.W.R.)

**28920** (NAA-SR-Memo-8968) THE RATRAP CODE — A MODIFICATION OF THE FARSE METHOD FOR SNAP SHIELD GEOMETRY. W. B. Green (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Sept. 13, 1963. Contract AT(11-1)-Gen-8. 45p.

The RATRAP code was written to compute a first order approximation to particle attenuation in shields for SNAP systems. The RATRAP code is now available for use on the IBM 7094 digital computer; it is a revision of the FARSE code (NSA 15: 19718) that is designed for use in preliminary investigation of shield sizes and weights for SNAP systems. The code computes total dose deposit at specified spatial points due to a specified source mesh; an attenuation model based on mean free paths traversed along a straight line is used. The removal cross sections used incorporate multiscattering effects. (auth)

**28921** (TID-20649) PROGRESS REPORT OF NORA PROJECT, SEPTEMBER 15, 1963–MARCH 15, 1964. (Norway. Institutt for Atomenergi, Kjeller). Contract AT (30-1)-2760. 37p.

Experimental results are summarized on: characteristics of $H_2O-D_2O$ mixtures as reactor moderators; lattice parameters and criticality characteristics of assemblies moderated with these water mixtures; thermal neutron distributions and transport in assemblies moderated with these mixtures; neutron lifetimes in subcritical reactors; neutron spectra in JEEP; measurement of the zero-power transfer function of NORA with $H_2O-D_2O$ moderator; the analysis of the reactivity parameters of NORA by the BIGG-K-7 THERMOS code; and the analysis of thermal neutron distributions in cells by the K-7 THERMOS code. (T.F.H.)

**28922** (WAPD-BT-30) BETTIS TECHNICAL REVIEW. REACTOR TECHNOLOGY. (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Apr. 1964. Contract AT-11-1-GEN-14. 99p.

Separate abstracts were prepared for 7 of the 9 sections;

2 were previously included in NSA as 18: 3139 and 7132. (R.E.U.)

*For abstracts of individual papers see: 27497, 28530, 28580, 29005, 29057, 29058, and 29059.*

**28923** REACTOR CLASSIFICATION AND DESIGN—MODERN CONCEPTS AND TRENDS. E. J. Umrigar. Nucl. Energy, 156-68(June 1964).

Types of reactors sponsored by the USAEC are listed, and discussion is presented on fundamental concepts, design specification data pertaining to different types of reactors, reactor theory for construction and operation, and basic requirements for reactors. (P.C.H.)

**28924** IN-PILE CAPSULE MEASUREMENTS OF STEAM-VOID FORMATION IN MILLISECOND POWER EXCURSIONS. L. B. Wentz (Space Technology Labs., Inc., Redondo Beach, Calif.). Trans. Am. Nucl. Soc., 7: 149-50(June 1964).

**28925** A METHOD FOR ESTIMATING ACTIVITY TRANSPORT IN PRESSURIZED WATER REACTORS FROM MEASUREMENTS IN LOOPS. G. N. Walton (United Kingdom Atomic Energy Authority, Harwell, Berks, Eng.). Trans. Am. Nucl. Soc., 7: 180-1(June 1964).

**28926** AUTORADIOGRAPHY: A TOOL FOR INVESTIGATING REACTOR-COOLANT-SYSTEM CONTAMINATION MECHANISMS. Lyle D. Perrigo and W. E. Taylor (General Electric Co., Richland, Wash.). Trans. Am. Nucl. Soc., 7: 181-2(June 1964).

**28927** THE EVALUATION AND MEASUREMENT OF REACTOR SAFETY PERFORMANCE. H. J. Larson and K. Stratton (General Electric Co., Pleasanton, Calif.). Trans. Am. Nucl. Soc., 7: 183(June 1964).

**28928** OPERATIONAL SAFETY EVALUATION OF REMOTE REACTOR PLANTS. A. J. Rizzo, M. S. Weinstein, J. E. McLaughlin, and W. M. Johnson (Atomic Energy Commission, New York). Trans. Am. Nucl. Soc., 7: 183-4(June 1964).

**28929** PREDICTION AND CONTROL OF LEAKAGE THROUGH CRACKS AND CAPILLARIES IN REINFORCED CONCRETE BUILDINGS USED TO HOUSE REACTORS. C. T. Nelson, A. S. Gibson, and R. L. Koontz (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 185(June 1964).

**28930** IMPROVEMENTS IN OR RELATING TO THE DETERMINATION OF NEUTRON FLUX DISTRIBUTION IN NUCLEAR REACTORS. Ronald Hugh Campbell (to United Kingdom Atomic Energy Authority). British Patent 960,761. June 17, 1964. Filed Jan. 11, 1962.

A method is given for determining the neutron flux distribution in a gas-cooled graphite-moderated reactor. The method comprises the steps of introducing a filament of argon into the reactor core, irradiating the filament for a period, subjecting the filament to a change in velocity, removing the filament from the core, and measuring the distribution of activity in the argon along the filament. Neutron-absorbing collars around the small tube through which argon is passed, are used for identifying selected points of the flux plot with the corresponding regions of the reactor core. An apparatus for carrying out the method and the "soak" and "step" modifications of the method are described. (D.L.C.)

## Auxiliaries and Components

*Refer also to abstracts 27658 and 28558.*

**28931** (EUR-1638.e) CAPSULE ASSEMBLY VIBRATION EXPERIMENT IN THE HIGH FLUX REACTOR (HFR). J. J. Geist (Société Grenobloise d'Etude et d'Applications Hydrauliques, Grenoble, France). 1964. 81p.

Experimental research work carried out on a simple case of tube vibration in a reactor is discussed. First the vibration is attributed to von Karman vortices and then this hypothesis is confirmed by calculation and experiment. It is shown that hazards of hydraulic origin can be determined and eliminated during the design phase of an experiment. (auth)

**28932** (EURAEC-1013) DEVELOPMENT PROGRAM ON THE APPLICATION OF STEAM–WATER SPRAY TO REACTOR COOLING. CAN 3 Quarterly Progress Report No. 9, January 1–March 31, 1964. (Centro Informazioni Studi Esperienze, Milan). Apr. 1964. Work Performed under United States–Euratom Joint Research and Development Program. Contract 056-62-1-RDI. 12p. (CISE-R-114)

Heat transfer experiments were pursued in the large scale loop in Genoa. Measurements of critical power and pressure drops were performed to study the influence of obstacles inserted in a simple round tube test section. These tests were considered important to understand the influence of spacers in more complex geometries. An annular test element was installed; a set of critical power and pressure drop measurements were performed with and without spacers. After in-pile corrosion tests and weight-gain measurements on Zircaloy-2, work has been done to equip a shielded cell for hydrogen pick-up determinations of the radioactive samples. An in-pile loop was partially modified for water chemistry and radiolysis experiments, and about 600 hours of in-pile tests were performed; more than 10 different situations were explored. Static corrosion tests and analysis of corrosion products were carried on. (auth)

**28933** (GEMP-82) REACTOR INSTRUMENTATION AND CONTROL PROGRESS REPORT NO. 82. (General Electric Co. Advanced Technology Services, Cincinnati). May 29, 1964. Contract AT(40-1)-2847. 25p.

The fabrication and testing of beryllia sensor specimens up to 2200°C in non-oxidizing atmospheres, and single-crystal alumina sensors at 1650°C oxidizing atmosphere, are reviewed. The change in the dielectric constant of the sensor with temperature is used to determine the temperature of a body being studied. Testing and evaluation of fission chambers and ionization chambers at temperatures to 816°C are reported. The development of a-c ionization chambers for use in monitoring and control systems of high-temperature, high-performance reactors is also discussed. (T.F.H.)

**28934** (IITRI-578P22-10) STUDIES OF REACTOR CONTAINMENT STRUCTURES. Bi-Monthly Progress Report No. 8262-9. R. L. Chiapetta and M. A. Salmon (Illinois Inst. of Tech., Chicago. IIT Research Inst.). June 1964. Contract AT(11-1)-578. 35p.

Analytic determination of the reduction in strength of containment vessels due to penetrations and of the amount of reinforcement required to restore the unpenetrated strength was pursued further. A computer program was written for calculations on spherical caps with rigidly reinforced circular openings. Also, the validity of the ana-

lytical methods previously developed for the prediction of the behavior of vessels with and without openings was experimentally tested. Static tests were performed on thin-walled cylindrical pressure vessels with different end closures, geometries, and materials. Flat circular plates with centrally-located, reinforced, circular holes were loaded by static lateral pressure. The experimental results for the cylindrical vessels are compared with the theoretical predictions, and preliminary results on the plates are given. (D.C.W.)

**28935** (IITRI-T6042-5) STUDIES OF REACTOR CONTAINMENT. Bimonthly Progress Report, December 1963–January 1964. E. V. Gallagher, comp. (Illinois Inst. of Tech., Chicago. IIT Research Inst.). Contract AT(11-1)-578. 19p.

Progress is reported on crushable shield analysis and design, shock impingement experiments on crushable shields, and coolant decompression testing. Debugging of the computer codes for calculation of wave transmission in layered composites of crushable materials showed that the number of stress wave interactions involved in some problems was quite large. The shock tube blast facility data were examined for the test specimen holder frictional effects on the motion of the crushing porous solid specimen. The data trends for the Hugoniot tests showed a close correspondence between the static and dynamic equations of state. The data trends for the isentrope paths in the stress-volume plane were dependent upon measurements taken in the downstream portion of the test specimen and in the very late portion of the observation time. An analysis is made of the wall friction influence upon the wave motion distribution in the impacted porous solid. The proposed scope for future experiments on the water shock tube is outlined. (N.W.R.)

**28936** (NYO-2907-2) EVALUATION OF AUTOMATIC FLOW BALANCING DEVICE IN BOILING WATER REACTORS. Final Report. Report No. 476. R. L. Mela, E. F. Doyle, and D. A. Gall (Dynatech Corp., Cambridge, Mass.). May 25, 1964. Contract AT(30-1)-2907. 55p.

Research on a device to control the exit steam quality in the individual fuel element assemblies of boiling water reactors is described. A prototype controller was constructed and successfully operated at the design conditions of saturated water at 1000 psia. Basic experimental work in two-phase fluid flow in support of the design was also conducted. A high pressure boiling water test loop was constructed to test the device. The design and operation of the loop are described. (auth)

**28937** (ORNL-3578(p.100-21)) REACTOR INSTRUMENTATION AND CONTROLS DEVELOPMENT. (Oak Ridge National Lab., Tenn.).

A system of reactor-control modules has been devised; each member is a functional unit of one or more transistor electronic instruments for reactor use. To date, 18 different modules have been designed and prototypes built. A current-sensitive amplifier was developed to amplify the current from the ionization chamber in the range of $10^{-6}$ to $10^{-3}$ amp. The amplifier has medium sensitivity, good stability, and high reliability. A study was begun to develop a fast-trip transistor comparator with an accuracy of ±25 mv over a range of 1 to 10 v and a temperature range of 10 to 55°C. The wide-range counting system was tested in the ORR, using components which include the ¾-in. flexible fission chamber and preamplifier assembly, and prototypes of some of the modules described. Reactor power and period were measured over eight decades (cold startup), as well as during normal startup, operation, and shutdown. By making the signal plates smaller than the positive and negative high-voltage plates in a parallel-circular-plate compensated ionization chamber, the effective volumes of the two portions can be varied by changing the ratio of positive to negative polarizing voltages. Both neutron and gamma sections are well saturated at voltages normally used, giving an electrically adjustable compensation independent of chamber current. A low-noise, solid-state, differential amplifier was developed for reactor noise studies and was designed to achieve long-term gain stability, a gain of 10,000, and a flat response within 1 db from 0.1 to 1000 cps. An automatic rod controller was designed for controlling the reactor outlet temperature over a range of 1100 to 1300°F. The ORNL Analog Computer Facility was used to establish design criteria. Analog studies indicate that the outlet temperature can be controlled within acceptable limits for all operating conditions between 1 and 10 Mw. A mechanical fission chamber positioner has been designed for use in the Molten-Salt Reactor Experiment. This positioner will be servo operated to maintain constant reactor power operation in the low- and medium-power regions. A design stroke of 90 in. and a design speed of 72 in./min will permit multidecade power-level control. Development and tests of a ball float and single-point molten-salt level indicators and of a temperature scanner were continued and are discussed. The feasibility of using closed-circuit television viewing systems during remote maintenance operations at the MSRE was investigated. A method was developed which counts the number of graphite balls flowing through a stainless steel pipe. A meter was designed to measure the water flow rate through the seat switches and clutch assemblies in the TSR-II reactor. The meter consists of a transducer, a preamplifier, a frequency meter, and a control meter. Output relays are utilized in the reactor safety circuits. Operating experiences with strain-gage pressure transducers used on in-pile experiments are discussed. Development and testing of thermocouple materials are summarized. A potted hermetic thermocouple seal was developed to seal the ends of sheathed thermocouples and connect them to 24-gage extension wires. (auth)

**28938** CONSTRUCTIONAL AND ASSEMBLY PROBLEMS IN THE INSTALLATION OF THE KAHL VAK EXPERIMENTAL LOOP. H. Facius (Allgemeine Elektrizitatsgesellschaft, Frankfurt am Main). Atomwirtschaft, 5: 213-19(May 1964). (In German)

The Kahl experimental atomic power station was taken out of operation in mid-April 1963 in order to install into the existing plant an experimental loop for the evaluation of superheating elements. While in the extension of a conventional plant by the installation of new components (containers, pipelines, fittings, etc.) it is possible to add to existing buildings, in Kahl it was necessary to remain inside the reactor building and, indeed, inside the pressure shell. The difficulties were enhanced not only by the relatively large number of new parts to be fitted but also by the very restricted space available. In order to adhere to the rigid time schedule, which provided five months for the construction and installation, it was necessary to carry out extensive preparatory work and largely to solve all expected problems and difficulties before the actual installation bega... At the commencement of construction 90% of all necessary materials and components such as containers, fittings, pipelines, control valves, measuring equipment, iron work, cables, etc. were on hand at the site, tested and stored according to the cycle of operations. It

was necessary to provide arrangements and make transport available to carry over 100 tons of concrete parts with individual weights of up to 14 tons quickly and safely to the reactor building. In particular numerous holes had to be bored through, in part, reinforced heavy concrete of 60 to 120-cm thickness. Because of the comprehensive planning and preparation of all work and supplies the time plan for the installation and testing was fulfilled. (auth)

**28939** REACTOR VESSEL RADIATION DAMAGE SHIELDING. Boris Rafailovic Bergelson (Inst. of Theoretical and Experimental Physics, Moscow). Jaderna Energie, 10: 152-6(May 1964). (In Czech)

Radiation damage shielding of construction parts and especially the nuclear reactor vessel is described. Studies were made of the shielding effects of heavy water and of graphite technical shields. The calculations started with the neutron slowing-down theory and were supplemented by the Peierls equation solution for half-space with a plane fission-neutron isotropic source. A method of calculation, which includes the influence of neutron energy, is described, which makes it possible to compare neutron flux calculations with experimental results for power reactors in different technological sections. (auth)

**28940** CRITICAL EVALUATION OF THE SAFETY SYSTEM OF A NUCLEAR REACTOR. C. Zaffiro and R. Zambrini. Riv. Ing. Nucl., 1: 209-15(Sept.-Oct. 1963). (In Italian)

The criteria that can be considered as the basis of the evaluation of a reactor safety system are examined. After a summary of the objectives and the various problems arising in an evaluation, the logical processes leading to solutions of the problems are examined. (tr-auth)

**28941** OPTIMAL CONTROL OF NUCLEAR REACTOR SYSTEMS. Ronald R. Mohler (Los Alamos Scientific Lab., N. Mex.). Trans. Am. Nucl. Soc., 7: 58-9(June 1964).

**28942** AN ADAPTIVE AUTOMATIC CONTROL OF A NUCLEAR REACTOR FOR A MINIMAL TIME RESPONSE. Isaac Kliger (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 59-60(June 1964).

**28943** MEASURED REACTIVITY WORTH OF VARIOUS THICKNESS SINGLE POISON STRIPS IN WATER-MODERATED REACTORS AT ROOM TEMPERATURE AND 500 F. Storrs Bigelow, W. C. Loomis, R. J. Cerbone, and J. A. Bistline (Knolls Atomic Power Lab., Schenectady, N. Y.). Trans. Am. Nucl. Soc., 7: 81-3(June 1964). (CONF-446-4)

**28944** DEVELOPMENT OF IMPROVED HEAVY-PLATE STEELS FOR NUCLEAR REACTOR PRESSURE VESSELS. John A. Gulya (Lukens Steel Co., Coatesville, Penna.). Trans. Am. Nucl. Soc., 7: 117(June 1964).

**28945** PRESSURE-SHELL NEUTRON-DAMAGE SATURATION AND EMBRITTLEMENT IN DEPTH: MONTE CARLO CALCULATIONS. J. R. Beeler, Jr. (General Electric Co., Cincinnati). Trans. Am. Nucl. Soc., 7: 124-5 (June 1964).

**28946** A COINCIDENCE ELECTROMAGNET FOR REACTOR SAFETY. W. D. Brown, S. H. Hanauer, and R. E. Wintenberg (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 135-6(June 1964).

**28947** ANALYSIS OF LOOSELY COUPLED TUBE SHEETS. James E. McConnelee (General Electric Co., Cincinnati). Trans. Am. Nucl. Soc., 7: 154-6(June 1964).

**28948** THE SELECTION OF PRESSURE VESSEL MATERIALS BASED UPON A FRACTURE MECHANICS ANALYSIS. E. Landerman, S. E. Yanichko, and W. S. Hazelton (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 157-8(June 1964).

**28949** CONTROL CHARACTERISTICS OF AXIAL COMPRESSORS IN PARALLEL-LOOP OPERATION FOR GAS-COOLED REACTORS. M. J. Kimbell (Kaiser Engineers, Oakland, Calif.) and E. R. Gasser. Trans. Am. Nucl. Soc., 7: 168-9(June 1964).

**28950** SOME DEPOSITION REACTIONS IN REACTOR COOLANT SYSTEM HEAT EXCHANGERS. Lyle D. Perrigo (General Electric Co., Richland, Wash.). Trans. Am. Nucl. Soc., 7: 182(June 1964).

**28951** REPLACEMENT OF MAJOR COMPONENTS IN SODIUM-COOLED REACTOR SYSTEMS. Ernest Hutter (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 190-1(June 1964).

**28952** IMPROVEMENTS IN OR RELATING TO THE ARREST OF FALLING BODIES WITHIN VERTICAL HOUSINGS. Percy Shutleworth Cavin and William Joseph Sidebottom (to United Kingdom Atomic Energy Authority). British Patent 960,717. June 17, 1964. Filed June 15, 1961.

A device is designed for slowing down a falling body in a vertical housing, particularly a control element in a reactor. The device comprises a friction shoe which, in the event of free fall of the body, is moved outwardly by displacement of a spring-restrained weight to contact the housing wall and thus arrest the fall. The device is described in conjunction with a facility for withdrawing boron-steel shot from the reactor core. (D.L.C.)

**28953** IMPROVEMENTS IN OR RELATING TO GAS COOLED NUCLEAR REACTOR. Pierre Dequenes (to Electricite de France (Service National)). British Patent 960,983. June 17, 1964. Priority date Nov. 15, 1961, France.

A safety means for preventing the blow-out of fuel cartridges from their channel during their unloading from gas-cooled reactors, is designed which is simple and operates automatically. The means creates a supplementary head loss at the outlet end of the channel by injecting a secondary supply of gas through orifices in the channel wall. Two embodiments of the means are described in which the secondary gas is supplied through lateral sides of the reactor and through an annular conduit around the control rod channels, respectively. (D.L.C.)

**28954** HEAT EXCHANGE APPARATUS AND NUCLEAR REACTOR DESIGNED FOR THE USE OF SAID APPARATUS. Didier Costes (to Commissariat a l'Energie Atomique). British Patent 961,277. June 17, 1964. Priority date Apr. 13, 1962, France.

A heat exchanger is designed which can be mounted within a reactor pressure vessel and in which repair and maintenance work can be performed to replace certain elements without putting the whole exchanger out of service. The exchanger comprises a casing inside which a first fluid circulates and an internal circuit through which circulates a second fluid. The internal circuit comprises identical elongated tubular elements whose length and transverse cross section are low fractions of these of the casing, the elements being removably assembled together by fluidtight coupling means. The heat exchanger is preferably located below the reactor core in the pressure vessel. (D.L.C.)

**28955** IMPROVEMENTS IN OR RELATING TO NUCLEAR REACTOR FUELLING DEVICES. Pierre Dequenes

(to Electricite de France (Service National)). British Patent 961,388. June 17, 1964. Priority date Nov. 13, 1961, France.

A reactor fuel-element handling device is designed which uses the levitation or blow-out phenomenon to move the fuel cartridge train into the device. The device comprises a charging-discharging machine adapted to connect to a reactor channel to form a circuit for the circulation of coolant between the machine and channel, means for adjusting the circulation so that the heat loss through the fuel train is sufficient to move the train, and a stop member between the train and machine. (D.L.C.)

**28956** FUEL FOLLOWER FOR A REACTOR CONTROL ROD. Thomas R. Murray, Harry N. Andrews, and Walter W. Fahrion (to Westinghouse Electric Corp.). U. S. Patent 3,138,536. June 23, 1964. Filed Sept. 6, 1960.

A follower device is designed for inhibiting flux peaking due to withdrawal of a cruciform control rod and for increasing the power output of the reactor. The follower device comprises a plurality of fuel rods forming a lateral cruciform envelope, ferrules for supporting the fuel rods in the envelope, and a latching member for securing the follower to the control rod. The follower is designed to prevent jamming. (D.L.C.)

**28957** DEVICES FOR DETECTING FISSIONABLE MATERIAL JACKET BURSTS IN NUCLEAR REACTORS. André Roguin and René Donguy (to Commissariat a l'Energie Atomique). U. S. Patent 3,138,710. June 23, 1964. Priority date Nov. 13, 1959, France.

A device for detecting fuel jacket bursts in gas-cooled reactors, is designed which is of the type in which a sample of coolant is held in a decay chamber to transform the short-lived fission products into positive ions which are then collected by a sector of a movable drum and detected when the drum sector is rotated into proximity of a detector. The sensitivity of the device is increased in several ways, such as increasing the number of ions collected by the drum sector, reducing the background noise, etc. The drum is caused to undergo both translatory and rotation movements, and its operation cycle is described. (D.L.C.)

## Criticality Studies

*Refer also to abstracts 28551 and 28552.*

**28958** (ACNP-64023) SHAPED BURNABLE POISON DEVELOPMENT PROGRAM UNDER THE EURATOM PROGRAM. Quarterly Progress Report, January 1, 1964–March 31, 1964. Pierre Descleve, Benjamin Fitts, Bruce Goss, and Patrick Lacy (Allis-Chalmbers Mfg. Co. Atomic Energy Div., Milwaukee). Apr. 20, 1964. Work Performed Under United States–Euratom Joint Research and Development Program. Contract AT(11-1)-1229. 23p. (EURAEC-1080)

Danger coefficient measurements were completed for all unirradiated poison capsules. The latest measurements included 32 capsules containing $Gd_2O_3$ lumped as either cylinders or wafers. Several of the $Gd_2O_3$ cylinder capsules also contained homogeneous $B_2O_3$ to provide a test of the analytical methods for the condition with neutron absorption between cylinders. Nine capsules containing $Gd_2O_3$ cylinders were irradiated in the MTR up to thermal neutron nvt values of $1 \times 10^{21}$. The effect of spatial variations in the thermal neutron spectrum incident on a poison capsule was investigated as a function of capsule $Gd_2O_3$ loading. Wafers of $Gd_2O_3$ were made with a process superior to that described earlier in that the density and quality are uniformly high. Annular extrusions of $UO_2$ containing $Gd_2O_3$ cylinders were fabricated and sintered to 3180°F. (auth)

**28959** (ANL-6733) A TWO-ZONE FAST CRITICAL EXPERIMENT (ZPR-III ASSEMBLY 42). P. I. Amundson, R. L. McVean, and J. K. Long (Argonne National Lab., Idaho Falls, Idaho). Jan. 1964. Contract W-31-109-eng-38. 36p.

The study was conducted to determine what properties of a previously studied dilute power reactor could be duplicated in a smaller two-zone assembly. Reactivity measurements performed included determinations of plate-orientation worth, homogeneity corrections, reactor-segment worths, central reactivity coefficients, and radial worth distributions of axial columns of core materials. Spectral index determinations included: central fission ratios, nuclear track emulsion measurements, fission counter traverses, Rossi-alpha measurements, sodium activation, and natural and enriched uranium foil measurements. (auth)

**28960** (NAA-SR-9390) NUCLEAR CONSIDERATIONS IN LOADING THE ECEL ASSEMBLY FOR THERMAL REACTOR DOPPLER EXPERIMENTS. R. H. Sevy (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). June 15, 1964. Contract AT(11-1)-Gen-8. 22p.

Various methods of providing a proper nuclear environment for resonance integral measurements are investigated. Criteria for evaluating the adequacy of a given environment for activation and reactivity measurements are established and applied to the ECEL critical assembly. (auth)

**28961** DETERMINATION OF NEUTRON EFFICIENCY FOR MULTISTAGED ANNULAR CELLS. V. P. Slizov (Inst. of Engineering Physics, USSR). Inzh. Fiz. Zh., 7: No. 1, 80-8(Jan. 1964). (In Russian)

The proposed method of calculation of $\Theta$ is based on the use of albedo and passing functions for a circle that may be tabulated preliminarily. The tabulation of these values depending on three variables $[\Sigma_1\delta, (R_+)/(R_-), (\Sigma_2)/(\Sigma_1)]$ will make it possible to easily and with sufficient accuracy determine $\Theta$ in circular cells without using electronic computers. Moreover, the knowledge of albedo and passing functions may be used to calculate effectiveness of multilayer circular control rods and in other problems. (auth)

**28962** OPTIMUM REACTOR-SHUTDOWN PROGRAM FOR MINIMUM XENON BUILDUP. Zoltan R. Rosztoczy and Lynn E. Weaver (Univ. of Arizona, Tucson). Trans. Am. Nucl. Soc., 7: 1-2(June 1964).

**28963** NONCONVERGENCE OF STEADY-STATE XENON CALCULATIONS. S. G. Margolis (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 2-3(June 1964).

**28964** A STABLE NUMERICAL SOLUTION OF THE REACTOR KINETICS EQUATIONS. W. W. Little, Jr., K. F. Hansen, E. A. Mason, and B. V. Koen (Massachusetts Inst. of Tech., Cambridge). Trans. Am. Nucl. Soc., 7: 3-4(June 1964).

**28965** COMPLEX EIGENVALUES IN KINETICS POWER REACTOR DIFFUSION CODES. H. E. Wrigley (Atomic Energy Research Establishment, Winfrith, Heath, Dorset, Eng.). Trans. Am. Nucl. Soc., 7: 6-7(June 1964).

**28966** APPLICATION OF THE DIRECT METHOD OF VARIATIONAL CALCULUS TO THE BOLTZMANN EQUATION. K. H. Mueller (Euratom, Ispra, Italy). Trans. Am. Nucl. Soc., 7: 9-10(June 1964).

**28967** THE FAILURE OF THE CELL CYLINDRICALIZATION APPROXIMATION IN CLOSELY PACKED URANIUM–HEAVY WATER LATTICES. R. Simms, I. Kaplan, T. J. Thompson, and D. D. Lanning (Massachusetts Inst. of Tech., Cambridge). Trans. Am. Nucl. Soc., 7: 9(June 1964).

**28968** APPLICATION OF FLUX SYNTHESIS TO PARAMETRIC-OPTIMIZATION STUDIES. N. J. Curlee, Jr. (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 12(June 1964).

**28969** TRANSPORT CALCULATIONS OF THE DISADVANTAGE FACTOR. Joel H. Ferziger and Alan H. Robinson (Stanford Univ., Calif.). Trans. Am. Nucl. Soc., 7: 12-13(June 1964).

**28970** TRANSPORT EFFECTS IN DIFFUSION THEORY. G. C. Pomraning (General Electric Co., Pleasanton, Calif.). Trans. Am. Nucl. Soc., 7: 13-14(June 1964).

**28971** TIME-DEPENDENT ONE-VELOCITY ALBEDO PROBLEM FOR A SEMI-INFINITE MEDIUM. I. Kuščer and P. F. Zweifel (Univ. of Michigan, Ann Arbor). Trans. Am. Nucl. Soc., 7: 14(June 1964).

**28972** ANALYTIC SOLUTIONS FOR THE WORTH OF A RING OF CONTROL RODS IN A MULTI-REGION CYLINDRICAL REACTOR. B. M. Carmichael (Los Alamos Scientific Lab., N. Mex.). Trans. Am. Nucl. Soc., 7: 32 (June 1964).

**28973** CALCULATION OF NEUTRON ABSORPTION RATIOS IN $D_2O$-MODERATED MIXED LATTICES. John E. Suich (E. I. du Pont de Nemours and Co., Aiken, S. C.). Trans. Am. Nucl. Soc., 7: 32-3(June 1964).

**28974** SIMPLIFIED METHOD FOR REPRESENTATION OF EPITHERMAL MULTIGROUP RESULTS IN FEW-GROUP FUEL-DEPLETION CALCULATIONS. R. L. Crowther (General Electric Corp., San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 33-4(June 1964).

**28975** DEPLETION OF CYLINDRICAL BURNABLE-POISON LUMPS. Pierre Descleve and Patrick Lacy. Trans. Am. Nucl. Soc., 7: 35(June 1964).

**28976** UNIT CELL HOMOGENIZATION. Harald A. Risti (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 35-6(June 1964).

**28977** DIMENSIONS OF PLUTONIUM CORES BY EXTRAPOLATION OF PERTURBED URANIUM CORES. D. Meneghetti and H. Ishikawa (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 37(June 1964).

**28978** PROPAGATION OF NEUTRON WAVES IN SUBCRITICAL ASSEMBLIES. R. B. Perez, R. S. Booth, R. S. Denning, and R. H. Harley (Univ. of Florida, Gainesville). Trans. Am. Nucl. Soc., 7: 49-50(June 1964).

**28979** POWER-SPECTRAL DENSITY OF THE NEUTRON-DENSITY FLUCTUATIONS AT A SINGLE POINT WITHIN AN INFINITE REACTOR. James R. Sheff and Robert W. Albrecht (Univ. of Washington, Seattle). Trans. Am. Nucl. Soc., 7: 61-2(June 1964).

**28980** ENERGY- AND SPATIAL-DEPENDENT TRANSFER AND IMPULSE RESPONSE FUNCTIONS. K. S. Ram and R. E. Uhrig (Univ. of Florida, Gainesville). Trans. Am. Nucl. Soc., 7: 62(June 1964).

**28981** ON THE VALIDITY OF THE PULSED-NEUTRON MEASUREMENT OF $K\beta/l$. J. L. Russell, Jr., J. R. Brown, and J. C. Young (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Trans. Am. Nucl. Soc., 7: 71 (June 1964).

**28982** NEUTRON-SPECTRUM MEASUREMENTS IN A ($UF_4$ + PARAFFIN) MULTIPLYING ASSEMBLY. J. C. Young, J. M. Neill, and J. R. Beyster (General Atomics Div., General Dynamics Corp., San Diego, Calif.). Trans. Am. Nucl. Soc., 7: 71-2(June 1964).

**28983** EFFECT OF SAMPLE SHAPE ON DECAY-CONSTANT MEASUREMENTS IN PARAFFIN. H. D. Curet, Y. P. Hwu, and A. Robeson. Trans. Am. Nucl. Soc., 7: 72-3(June 1964).

**28984** EXTRAPOLATION TO CRITICALITY USING THE DIE-AWAY TECHNIQUE IN $D_2O$-MODERATED LATTICES. T. F. Parkinson, R. B. Perez, N. J. Diaz, and J. D. Eckard, Jr. (Univ. of Florida, Gainesville). Trans. Am. Nucl. Soc., 7: 73-4(June 1964).

**28985** INTERNAL THERMAL-COLUMN EXPERIMENTS WITH $ThO_2/UO_2$-FUELED, $D_2O$-MODERATED AND -REFLECTED CORES. E. M. Pennington and K. E. Plumlee (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 74(June 1964).

**28986** EXPERIMENTAL BUCKLINGS AND NEUTRON-DENSITY RATIOS OF $D_2O$-MODERATED MIXED LATTICES. F. D. Benton and W. E. Graves (E. I. du Pont de Nemours & Co., Aiken, S. C.). Trans. Am. Nucl. Soc., 7: 74-5(June 1964).

**28987** TEMPERATURE OPERATION OF AN UNPRESSURIZED NATURAL-URANIUM HEAVY-WATER ASSEMBLY. D. G. Andrews (Univ. of Toronto) and I. F. Freibergs. Trans. Am. Nucl. Soc., 7: 75-6(June 1964).

**28988** STUDY OF A SLIGHTLY ENRICHED $UO_2$ LATTICE WITH HYDROGEN/URANIUM = 0.42–MEASUREMENT AND ANALYSIS. W. Baer, J. Hardy, Jr., D. Klein, J. J. Volpe, B. L. Palowitch, and F. S. Frantz, Jr. (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 79-80(June 1964).

**28989** INITIAL CONVERSION RATIO AND EPICADMIUM TO SUBCADMIUM URANIUM-238 CAPTURE RATE MEASUREMENTS IN VERY UNDERMODERATED SLIGHTLY ENRICHED OXIDE CORES. Q. L. Baird, A. R. Boynton, W. R. Robinson, and J. M. Christenson (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 80-1(June 1964).

**28990** HOMOGENEOUS CRITICAL EXPERIMENTS WITH PLUTONIUM/PLASTIC MIXTURES IN THE INTERMEDIATE ENERGY RANGE. C. R. Richey, J. D. White, R. C. Lloyd, and E. D. Clayton (General Electric Co., Richland, Wash.). Trans. Am. Nucl. Soc., 7: 81(June 1964).

**28991** CALCULATIONS ON COHERENCE OF FAILURE IN HYPOTHETICAL MELTDOWN ACCIDENTS IN AN EBR-II-LIKE REACTOR. D. V. Gopinath, C. E. Dickerman, and L. Bryant (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 138(June 1964).

**28992** HYPOTHETICAL FAST OXIDE REACTOR MELTDOWN ACCIDENT WITH DOPPLER EFFECT. B. Wolfe, N. Friedman, and R. Meyer (General Electric Co., San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 138-9 (June 1964).

**28993** NEW TOOLS FOR REACTOR-EXCURSION ANALYSIS. J. A. Redfield, K. J. Chock, and S. G. Mar-

golis (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 139-40(June 1964).

**28994** USE OF DEPLETED URANIUM IN THERMAL REACTORS WITH SLIGHTLY ENRICHED FUEL TO ACHIEVE HIGH NEUTRON ECONOMY AND BURNUP. Haig P. Iskenderian (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 197-8(June 1964).

**28995** SPACE DEPENDENT EFFECTS IN THE RESPONSE OF A NUCLEAR REACTOR TO FORCED OSCILLATIONS. William E. Loewe (IIT Research Inst., Chicago) 45p. (CONF-187-128)

From the American Nuclear Society Meeting, New York, Nov. 1963.

The two-group neutron diffusion equations were applied to nonuniform reactors to obtain the transfer function for an arbitrarily located, localized oscillatory absorber and point of observation. Data obtained from a digital computer program written for the case of symmetrical slab geometry amplify previous work on space-dependent, zero-power transfer functions and establish criteria for calibrating reactor control rods by oscillation. Simple physical models suggested to explain the space dependent effects imply generality. (auth)

## Design and Feasibility

**28996** (AEEW-R-283) AN ANALYTICAL AND EXPERIMENTAL STUDY OF THE BEHAVIOUR OF REDUNDANT CONTROLLERS APPLIED TO A NUCLEAR PLANT. L. A. J. Lawrence (United Kingdom Atomic Energy Authority. Reactor Group. Atomic Energy Establishment, Winfrith, Dorset, England). Feb. 1964. 74p.

The behavior of a number of configurations of redundant controllers is examined, and the design problems are discussed in relation to the engineering of reliable control rod drive systems for nuclear plant. (auth)

**28997** NUCLEAR REACTOR. John Arthur Geoffrey Holmes and Harry Hayes (to United Kingdom Atomic Energy Authority). British Patent 961,084. June 17, 1964. Filed June 1, 1962.

A pebble-bed reactor is designed with a plurality of separate reactor vessels to prevent stagnation of the pebbles. The reactor comprises seven vessels (six arranged around a central vessel), each vessel having a fuel inlet, a fuel outlet, and a conical base converging toward the outlet with an included angle less than 90°. The core structure is supported on a diagrid with thermal insulation in the form of a honeycomb, and a gaseous coolant is passed downward through the vessels. (D.L.C.)

## Fuels

*Refer also to abstract 28070.*

**28998** (AERE-R-4260) REPORT OF A HIGH-TEMPERATURE REACTOR FUEL DISCUSSION GROUP. K. D. B. Johnson (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Apr. 1964. 52p.

The results of a discussion group on requirements for future research and development in high-temperature reactor fuels, based mainly on coated fuel material, are presented. Particular emphasis is placed on graphite-moderated systems having carbide-based fuel; oxides are considered in less detail. Phase stability, thermal conductivities, diffusion, and fission-product retention characteristics of several fuels are discussed. Uranium–thorium–graphite, uranium–thorium–carbon, pyrolytic graphites, uranium dicarbides, and carbide coatings are discussed. (R.E.U.)

**28999** (GEAP-4407) DESIGN AND FABRICATION OF PELLET FUEL RODS CLAD WITH THIN-WALL STAINLESS STEEL. AEC Fuel Cycle Program, Assembly 8L. J. P. Hoffmann (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). Feb. 1964. Contract AT(04-3)-189. 30p.

Stainless-steel-clad nuclear fuel cycle costs can be reduced to those associated with Zircaloy-clad fuel or potentially lower by reducing the thickness of the clad tube wall until performance penalties offset the savings associated with the reduction in parasitic neutron absorption. To demonstrate the feasibility and investigate performance capabilities of thin clad fuel rods for power reactor application an assembly was fabricated with 0.0127-cm thick stainless steel cladding tubes for irradiation testing in the Vallecitos Boiling Water Reactor. The fuel rod design configuration for the assembly, designated AEC Fuel Cycle Special Assembly 8L, is summarized:

| | |
|---|---|
| Tube Material | Type 304 stainless steel |
| Tube Inside Diameter | 0.953 cm nominal |
| Tube Wall Thickness | 0.0127 cm nominal |
| Rod Length | 116.3 cm |
| Fuel Form | Pellets |
| Pellet Diameter | 0.940 cm |
| $UO_2$ Weight per Rod | 670 to 680 grams |
| Fuel Enrichment | 4.58 percent |
| Clad to Pellet Gap | Swaged |
| Fuel Rod Diameter | 0.965 cm nominal |

The fuel bundle was placed in the VBWR and irradiation was begun in November, 1961. The irradiation is scheduled to continue until the target exposure of $2.74 \times 10^{20}$ fissions/cc (10,000 Mwd/t of uranium) average burnup is reached. Destructive examinations of fuel rods will be performed at regular intervals throughout life to determine fuel rod performance. (auth)

**29000** (GEAP-4503) ACCURATE NUCLEAR FUEL BURNUP ANALYSES. Ninth Quarterly Progress Report, December 1963–February 1964. B. F. Rider, J. P. Peterson, Jr., C. P. Ruiz, and F. R. Smith (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). Mar. 1, 1964. Contract AT(04-3)-189. 24p.

The development of accurate methods of determining fuel burnup was continued. The neutron activation cross section of $^{148}Nd$ was measured because of its value as a burnup indicator. Post-irradiation examination of the GEV-2 assembly after removal from VBWR was begun; cobalt, iron, and nickel flux wires were removed from within the capsules of $^{235}U$, $^{239}Pu$, and $^{238}U$ for measurements of thermal and fast neutron exposure. The Cd filter from GEV-2 was mass analyzed for $^{113}Cd$ burnout; the cadmium oxide was not affected by melting. The $^{113}Cd$ burnout was also calculated and compared with experimental results. (R.E.U.)

**29001** (HW-79280(p.5.1-25)) FUELS STUDIES. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

$PuO_2$–MgO Phase Studies. $UO_2$–$PuO_2$ Synthesis. $\beta$-$Pu_2O_3$ Compatibility. Electron Microscope for Plutonium Studies. Plutonium Cermets. Plutonium Dioxide Spheres. Infrared Absorption Spectrum of $ThO_2$. Thermal Diffusivity

Measurements. Induction Coupled Plasma. An induction coupled plasma torch for use in high temperature research has been developed. Irradiation Testing of Th–U Fuel Elements. A volume increase of 0.5% at the end of the fourth cycle and exposure of 3400 Mwd/ton was observed. Fuel performance throughout irradiation was judged excellent. Thoriuum Fuel Defect Testing. Defect testing of Zircaloy-2 clad Th–2.5 wt % U–1 wt % Zr core, fuel rod specimens was initiated. Thermocoupled Fuel Elements. End closure brazing procedures were developed for brazing three different end closure configurations on Zircaloy-2 clad, Th–U thermocoupled elements. Corrosion Studies of Thorium-Contaminated Braze Alloy. Dispersed Phase Thorium Alloys. Th–U–Zr alloys with added aluminum or beryllium were prepared and hardness tested. Fabrication of Zircaloy-2 Clad Th–U–Zr Alloys. Th–U–Zr alloys of 10 compositions were prepared for testing. EBWR Plutonium Fuel Elements. Construction of the new vibrational compaction facility was completed. Preparation and Purification of $PuO_2$. $PuO_2$ obtained by burning plutonium metal in air was found to be strongly contaminated by halides. PRTR Fuel Element Fabrication. All PRTR $UO_2$–$PuO_2$ fuel elements are now prepared by pneumatic impaction. Pneumatic Impaction of PRTR Fuel Material. One hundred fifty pounds of $UO_2$–1 wt % $PuO_2$ was impacted to 98.8% TD in a single day. Particle Size Distribution of $PuO_2$ Powders. Cermet Fuel Volatization. PuC Cermets. Cermets were fabricated by pneumatically impacting arc melted PuC in matrices of tantalum, molybdenum, or tungsten. Preparation of $PuO_2$-Stainless Steel Cermets. The first $PuO_2$-SS cermet made by pneumatic impaction (at 1000°C) was metallurgically examined and found to be sound. Magnetic Force Welding Studies. Burnable Poison Distribution. Irradiation Performance of MgO–$PuO_2$ Fuel. Irradiation Performance of $ZrO_2$–$PuO_2$ Fuel. $ThO_2$–$PuO_2$ Irradiation Studies. PRTR Fuels Compatibility. Determination of Halides in $PuO_2$ Supplies. Plutonium Compounds Irradiation. Radiation Damage to $UO_2$. Structure Development in $UO_2$ During Irradiation. Long Term Irradiation of Cermet Fuels. Short Term Irradiation of W–$UO_2$ Cermets. Irradiation of High Heat Flux Fuel Rod. Postirradiation Examination of Electrical Resistivity Test Element. Fuel Element Rejuvenation. The rejuvenated fuel element is in its third cycle of irradiation. Fuel Element Design Studies. A ring type end bracket was found to eliminate process tube wear in an out-of-reactor loop. PRTR Fuel Element Performance. Postirradiation Examination of Failed PRTR Fuel Elements. Internal corrosion caused cladding failure in some vibrationally compacted $UO_2$–$PuO_2$ PRTR fuel rods. Postirradiation Examination of Failed Swaged PRTR Fuel Elements. Irradiation of Non-autoclaved PRTR Fuel Element. Increased fuel element life was indicated. (auth)

**29002** (HW-80284(p.5.1-14)) FUELS STUDIES. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

$UO_2$ losses from $UO_2$–50 wt % W cermet during annealing at 2000 to 2600°C in argon and hydrogen were studied. Surface crystallization and vaporization of $UO_2$ from $UO_2$–W cermet at 3100°C were studied. Diametral tensile tests were performed on impacted $UO_2$–W. The high-temperature behavior of aged UC crystals was studied. Some high-temperature properties of PuC–TaC and PuC–ZrC were studied to find a high-melting-point plutonium compound. Irradiation tests were performed on Th–2.5 wt %–U–1.0 wt % Zr in the ETR P-7 facility to study swelling of the tubular elements. Defect tests on Zircaloy-2 clad, Th–U–Zr fuel rod specimens in 300°C water were carried out. Irradiation tests were performed on Zircaloy-2 clad, Th–U thermocoupled element. Hardness and extrusion of Th–U–Zr alloys were studied. Studies were initiated on the ability of a submicron dispersion of UC to reduce uranium swelling. A UN–20 wt % PuN solid solution was prepared for irradiation testing by sintering pellets in nitrogen at 1800°C. Fission-product migration in irradiated $UO_2$–$PuO_2$ pellets was studied. Preparation of 98% TD $UO_2$–$PuO_2$ by high-energy impacting is reported. Fission-gas release and lattice dilation were studied in irradiated $UO_2$ single crystals. The development and testing of $UO_2$–$PuO_2$ fuel elements for PRTR are discussed. (R.E.U.)

**29003** (HW-SA-3104) DESIGN OF END CAPS FOR REACTOR FUEL ELEMENTS. Kenneth R. Merckx (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 19, 1963. Contract [AT(45-1)-1350]. 24p.

Parametric studies were made for bending and shear stresses in the relatively thick transition zone between the end cap and the cladding. It was found that the stresses could be decreased several times with properly shaped transitions. For a linear thickened transition, definite ratios of transition length to cladding thickness give minimum bending stress conditions where the bending stresses are constant over the transition length. Shearing stresses are 0.2 to 0.1 of the bending stresses for realistic cladding thickness-to-radius ratios. The height-to-length ratio is more critical for linear transitions than for curved transitions. (D.L.C.)

**29004** (ORNL-3639) GAS FLOW CALCULATIONS FOR FLUIDIZED-BED COATING OF NUCLEAR FUEL PARTICLES. R. L. Pilloton (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 56p.

Calculations of gas flow requirements and of other related parameters in the fluidized-bed process used to coat nuclear fuel particles are presented. These data include: volumes and surfaces of spheres for diameters of 50 to 500 $\mu$; number of these spheres in one gram for densities of 2 to 11 g/cm$^3$; overall densities of coated spheres for initial particle diameters of 50 to 500 $\mu$, initial densities of 8 to 11 g/cm$^3$, coating densities of 1.0 to 2.2 g/cm$^3$, and final particle diameters of 100 to 1000 $\mu$; viscosities of argon, carbon dioxide, helium, and hydrogen for temperatures up to 2200°C; minimum flows of helium and argon necessary to fluidize nuclear fuel particles at 20°C; coefficients for converting the 20°C minimum fluidization gas flows to high-temperature flows (up to 2200°C); variation of particle diameter with time for constant weight deposition rate; variation of coating gas flow for constant linear growth of the coating; and comparison of coating time at constant weight deposition rate and at constant coating growth rate. (auth)

**29005** (WAPD-BT-30(p.23-30)) DEFORMATION ANALYSIS OF FUEL GROWTH IN FUEL PLATES. R. J. Scavuzzo (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh).

A deformation analysis of fuel growth in fuel plates, which is based on the thermal expansion model, is presented. Results of this simplified analysis are shown to be in good agreement with theoretically more exact PLASTIC-SASS-1 calculations. (auth)

**29006** (EURAEC-1009) NUCLEAR VAPOTRON. Special Report No. 3. (Compagnie Francaise Thomson-Houston, Paris and Société Alsthom, Paris). Nov. 20, 1963. Work Performed under United States–Euratom

Joint Research and Development Program. Contract 050-62-5RD-C. 177p. (A translation)

The "nuclear vapotron" consists of a reactor fuel can having an irregular outer cross section (gear-toothed, triangular, triangular with blunted corners, square, etc.), whose purpose is the stabilization of the thermal-hydraulic characteristics of the cooling water flowing past the fuel. The vapotron fuel element is designed for use in boiling water reactors. The report contains results of out-of-pile tests of the heat transfer characteristics of various candidate shapes, using electrically heated, hollow, stainless steel rods. The testing equipment is also described. (T.F.H.)

**29007** URANIUM FOR PLATE-TYPE URANIUM–ALUMINUM FUEL ELEMENTS. H. Eschnauer (Nuklear-Chemie und -Metallurgie G.m.b.H., Wolfgang bei Hanau am Main, Ger.). Atomwirtschaft, 5: 229-30(May 1964). (In German)

The fuel for plate-type U–Al fuel elements for research reactors is today usually 90% enriched U. So far 90% enriched U hexafluoride can be obtained only from the USAEC. It is leased on the basis of existing bilateral government contracts and passed on in sub-lease quantities to government or private institutes or companies for peaceful use. In every case 90% enriched U is transferable only between governments. In the Euratom area Euratom procures the 90% enriched U hexafluoride from the USAEC in accordance with the Euratom-USA Agreement. Moreover the German Federal Republic can, like every other Euratom country, obtain 90% enriched U hexafluoride for a German reactor by virtue of the existing bilateral German-American Government Contract. Plate-type U–Al fuel elements manufactured from this material in Germany may be supplied to a third country only by way of re-export if that country has likewise concluded bilateral agreements with the American Government. This is the case with more than 50 western countries. (auth)

**29008** RESEARCH ON CERAMIC-COATED PARTICLES FOR NUCLEAR FUELS. Comit. Nazl. Energia Nucl., Notiziario, 10: No. 5, 40-2(May 1964). (In Italian)

Research carried out in the United States on ceramic-coated spherical particles of nuclear fuel used in high-temperature gas-cooled reactors is reviewed. (auth)

**29009** THE NUCLEAR FUEL PLUTONIUM. Claude Benoit. Sci. Progr.–Nature, No. 3348, 127-34(Apr. 1964). (In French)

The properties, suitability, and preparation of plutonium for use as reactor fuel are discussed. Its exceptional allotropy, alpha emission, and separation from uranium are reviewed, together with the alloys that permit its use in reactors. The $PuO_2$–$UO_2$ fuel of the Rapsodie reactor is also discussed. (D.C.W.)

**29010** THE APPLICATION OF DYNAMIC PROGRAMMING TO FUEL-MANAGEMENT OPTIMIZATION. Henri Fenech and Ian Wall (Massachusetts Inst. of Tech., Cambridge). Trans. Am. Nucl. Soc., 7: 7-8(June 1964).

**29011** DEMONSTRATION OF FISSION-GAS VENTING FROM FAST OXIDE REACTOR FUEL ELEMENTS. G. L. O'Neill, J. H. Davies, and M. L. Johnson (General Electric Co., San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 92-3 (June 1964).

**29012** FISSION-PRODUCT FRACTIONATION DURING IN-PILE DESTRUCTION OF REACTOR FUELS. C. E. Miller, Jr., W. E. Browning, Jr., B. F. Roberts, and R. P. Shields (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 96-7(June 1964).

**29013** A RAPID TEST OF FISSION-PRODUCT-RETENTION CHARACTERISTICS OF COATED FUEL PARTICLES. P. E. Gethard, C. C. Adams, and L. R. Zumwalt (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Trans. Am. Nucl. Soc., 7: 96(June 1964).

**29014** FLUX AND PIN-TO-PIN POWER RATIO MEASUREMENTS OF IRRADIATED FUEL FROM FISSION-GAS ANALYSIS. Howard S. Dreyer (Lockheed Missile and Space Co., Sunnyvale, Calif.). Trans. Am. Nucl. Soc., 7: 97-8 (June 1964).

**29015** MATERIAL STUDY OF A BARIUM OXIDE URANIUM OXIDE TUNGSTEN CERMET NUCLEAR THERMIONIC EMITTER. Robert F. Hill and Fay E. Gifford (General Motors Technical Center, Warren, Mich.). Trans. Am. Nucl. Soc., 7: 102-3(June 1964).

**29016** SODIUM-LOGGING BEHAVIOR OF FAST OXIDE REACTOR FUEL. G. L. O'Neill, P. E. Novak, and M. L. Johnson (General Electric Co., San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 107-9(June 1964).

**29017** PROCESS DEVELOPMENT OF URANIUM CARBIDE FUEL ELEMENTS FOR LARGE SODIUM/GRAPHITE REACTORS. D. K. Magnus (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 110-11(June 1964).

**29018** PERFORMANCE OF STAINLESS-STEEL-CLAD $UO_2$ FUEL ELEMENTS IN A BORATED PWR LOOP. D. R. McClintock and C. J. Kubit (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 120(June 1964).

**29019** EVALUATION OF A GAS-COOLED REACTOR FUEL ELEMENT AFTER 10 000 HOURS IRRADIATION. J. S. Brunhouse and G. W. Titus (Aerojet-General Nucleonics, Azusa, Calif.). Trans. Am. Nucl. Soc., 7: 127-8 (June 1964).

**29020** PHOTOGRAPHIC EXPERIMENTS ON MELTDOWN OF IRRADIATED METALLIC URANIUM FUEL PINS. C. E. Dickerman and L. E. Robinson (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 137(June 1964).

**29021** TRANSIENT HEATING EXPERIMENTS WITH URANIUM CARBIDE FUEL. S. J. Stachura, M. Silberberg, and R. N. Cordy (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 150-1(June 1964).

**29022** THERMAL BOWING OF FUEL RODS DURING TRANSIENTS. William K. Ergen (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 160(June 1964).

**29023** THE DESIGN AND ECONOMIC EVALUATION OF BLANKETS FOR FAST REACTORS. Alton E. Klickman, George L. Ball, Jack J. Edwards, Ben M. Segal, and Robert C. Williams (Atomic Power Development Associates, Inc., Detroit). Trans. Am. Nucl. Soc., 7: 178 (June 1694).

**29024** THE RELATIVE EFFECT OF PHYSICS-PARAMETER UNCERTAINTIES ON CORE PERFORMANCE AND COMPUTED FUEL-CYCLE COSTS FROM PERTURBATION METHODS. W. A. Reardon and R. L. Watts (General Electric Co., Richland, Wash.). Trans. Am. Nucl. Soc., 7: 198-9(June 1964).

**29025** SOME ASPECTS OF THE NUCLEAR FUEL FABRICATION INDUSTRY. G. C. Brown (Canadian Westinghouse Co. Ltd., Port Hope, Ont.). 12p. (CONF-539-5)

From Canadian Nuclear Association Conference on Canada's Role in a World of Expanding Nuclear Industry, Toronto, May 1964.

The economics of fuel fabrication in Canada are discussed. Calculations are given for a 500-Mw(e) power reactor to be built in Canada. (P.C.H.)

**29026** DEVICE FOR CENTRING [CENTERING] FUEL ELEMENTS IN NUCLEAR REACTORS. Bernard Boudouresque and Pierre Rouge (to Commissariat a l'Energie Atomique). British Patent 960,813. June 17, 1964. Priority date Apr. 20, 1962, France.

A device for centering a finned fuel element of the herringbone type in a gas-cooled reactor is designed which is simple and has reduced neutron absorption. The device comprises at least three centering blades with their planes directed toward the axis of the fuel element, the blades being fast with the sleeve structure and in contact with the sheath or vice versa. Since the herringbone fins eliminate turning forces, the centering blades need to be rigid only in the longitudinal and radial directions, and a series of openings are provided in the blades to reduce neutron absorption. (D.L.C.)

**29027** FUEL ELEMENTS FOR NUCLEAR REACTORS. Richard Valentine Moore and August Roumph (to United Kingdom Atomic Energy Authority). U. S. Patent 3,137,635. June 16, 1964. Priority date June 24, 1957, Great Britain.

A fuel element assembly is designed for use with a thimble-shaped coolant channel in reactors of the reentrant cooling type, particularly sodium graphite reactors. The assembly comprises a plurality of sleeves endfitting with each other to extend along the interior of the thimble, fuel elements supported within each sleeve, and removable pins connecting together the sleeves at the endfitting regions. Thus, the stack of sleeves may be dismantled and reassembled in a different order for more uniform burnup of the fuel elements. (D.L.C.)

**29028** FUEL ELEMENTS FOR NUCLEAR REACTORS. Edward Rae Elliott (to C. A. Parsons and Co. Ltd.). U. S. Patent 3,137,637. June 16, 1964. Priority date Jan. 13, 1958, Great Britain.

A reactor tube assembly for gas-cooled graphite-moderated reactors is designed which effects a helical coolant flow without the use of fins. The assembly comprises a series of tubes arranged to form a tubular framework with the tubes parallel to the framework axis and an axially extending support member having radially extending walls which support the tubes and baffle the spaces between the tubes. The radially extending walls are twisted to form a helical pattern and have recesses for receiving the tubes, and the hub of the support member may contain an aperture through which a control rod can be passed. The tube assembly may be enclosed by a graphite sleeve. (D.L.C.)

**29029** NEUTRONIC REACTOR FUEL ELEMENTS. Hermann Kumpf and Kans Kroepfl (to Siemens-Schuckertwerke AG). U. S. Patent 3,137,638. June 16, 1964. Priority date May 23, 1959, Germany.

A lateral joining means is designed for reinforcing the individual fuel rods of a fuel assembly along its length. The joining means comprises undulated (corrugated) bands which engage slidably the individual fuel rods so that little or no welding or brazing is needed and no restriction of coolant flow occurs. Several embodiments of the joining means are described. (D.L.C.)

**29030** FUEL ELEMENTS FOR NUCLEAR REACTORS. Andrew Thomson Bowden (to C. A. Parsons and Co. Ltd.). U. S. Patent 3,138,537. June 23, 1964. Priority date Nov. 12, 1957, Great Britain.

A canned fuel element is designed to minimize differential expansion between the fuel and the can. The fuel is provided with a plurality of spaced recesses or grooves over its length, the recesses being more closely spaced at the ends than in the middle because of the higher stresses. The can is forced into the recesses by pressure. (D.L.C.)

**29031** FUEL ELEMENTS FOR NUCLEAR REACTORS. Andrew Thomson Bowden (to C. A. Parsons and Co. Ltd.). U. S. Patent 3,138,538. June 23, 1964. Priority date Nov. 12, 1957, Great Britain.

A canned fuel element of the type having recesses in the fuel which interlock the can and fuel, is designed to minimize the barreling effect, that is, the tendency of the can to spring away from the fuel in the central portion of the fuel element. The recesses are shaped in a wedge or other form which tends to lock the can in the recesses against radial movement. These shaped recesses may be used in conjunction with the closer spacing of the recesses at the ends of the fuel element, as described in U. S. Patent 3,138,537. (D.L.C.)

## Power and Power-Breeder Reactors

**29032** (ACNP-64503) LARGE FAST REACTOR DESIGN STUDY. Final Report. (Allis-Chalmers Mfg. Co. Atomic Energy Div., Milwaukee; Atomic Power Development Associates, Inc., Detroit; and Babcock and Wilcox Co. Atomic Energy Div., Lynchburg, Va.). Jan. 1964. Contract AT(11-1)-1316. 275p.

The results of a study on a 1000-Mwe plant using an Na-cooled, fast-breeder reactor fueled with steel-clad Pu–$UO_2$ are presented. The results show that a practical 1000-Mwe reactor with a sodium outlet temperature of 1200°F and a breeding ratio of 1.32 can be designed having a fuel-cycle cost of 0.69 mills/kwh at a plant factor of 0.8. The use of an annular core essentially eliminated the large positive sodium-void-reactivity coefficient normally found in comparable cores. Details of the analyses performed, the proposed design, and the associated systems are presented. (D.C.W.)

**29033** (ANL-6772) MEASUREMENT OF WATER-CHANNEL GAPS IN EBWR CORE-I FUEL ELEMENTS. C. F. Reinke and W. N. Beck (Argonne National Lab., Ill.). Mar. 1964. Contract W-31-109-eng-38. 16p.

An eddy-current technique was developed for measuring water-channel gaps on EBWR Core-I fuel elements under water in the EBWR reactor vessel. Actual measurements were made with a modified commercial eddy-current detection device before and after 100-Mw operation of the EBWR. Before high-power operation, the channels ranged from about 8.4 mm (0.330 in.) to greater than the reference value of 11.1 mm (0.438 in.). After 100-Mw operation, the minimum water gap was found to be about 10.2 mm (0.400 in.). The data indicate that swelling (if any occurred) was negligible and masked by a loss of oxide from the fuel-plate surfaces. (auth)

**29034** (ANL-6843) USE OF DEPLETED URANIUM IN THERMAL REACTORS WITH SLIGHTLY ENRICHED FUEL, TO ACHIEVE HIGH NEUTRON ECONOMY AND HIGH BURNUP. Haig P. Iskenderian (Argonne National Lab., Ill.). Feb. 1964. Contract W-41-109-eng-38. 22p.

Average burnup capabilities of two cores with Zircaloy as structural material and slightly enriched (2.3 to 2.7% enrichment) and depleted (0.2% enrichment) fuel elements in the ratio of 1 to 3 in numbers, or their volume equivalents, are given. The possibilities for high burnup in EBWR Core B were contrasted with the hot spots occurring at the interfaces between the "D" and "E" elements.

It was, however, shown that for Core B there is a flattening in the power characteristics because of the rise of thermal flux in the "D" elements, which compensates for the deleterious effects of the hot spots. The latter were somewhat reduced by the use of fuel sections with enrichments intermediary to those of the "D" and "E" elements. In the calculations, no allowance was made for Xe + Sm poisoning. This will amount to about 3% $\rho$, which requires, according to some of our calculations, an increase in the enrichment of "E" elements of Core B from the present 2.7% to 3.0%. The average enrichment of the core will then be 2.3%. There will be a rise in core reactivity of about 4.6% $\rho$ with burnup. In general, however, it may not be feasible to absorb the Xe + Sm poisoning effect with this rise. The increased enrichment and reactivity to be controlled will reduce the conversion ratio of the core, and the total average calculated burnups of 12,600 Mwd/ton will be reduced by about (estimated by extrapolation) 600 Mwd/ton. The economic advantages in the use of the proposed core are: decreasing feed enrichment and, therefore, inventory; burning more plutonium in place (also a result of lower enrichment); and building up more plutonium from the higher conversion ratio (initially, average breeding rate is 0.74 for the core). (auth)

**29035** (CEND-200(Vol.I)) LIQUID METAL FAST BREEDER REACTOR DESIGN STUDY. VOLUME I. INTRODUCTION—SUMMARY AND EVALUATION—DESCRIPTION OF THE PLANT. (Combustion Engineering, Inc. Nuclear Div., Windsor, Conn.). Jan. 1964. Contract AT(11-1)-1317. 89p.

The primary objective of the study was to develop a conceptual design of a large sodium-cooled fast breeder reactor of a nominal electrical rating of 1000 Mw operating on the uranium–plutonium cycle. In accordance with the scope of the study, the primary emphasis was placed on the reactor, the primary heat removal loops, and the fuel handling equipment. The technology is consistent with a schedule that calls for the building of a prototype plant of 200 Mw electrical rating in the early 1970's and the building of the 1000 Mw(e) plant in the late 1980's. Another objective was to define a research and development program for the reactor. The following guidelines were specified for the present study: (1.) the reactor is to fueled with mixed plutonium and uranium carbides; (2.) the reactor will need only fertile material make-up from outside the core and blanket cycle. This depleted uranium is to be of 0.3 wt.% $^{235}U$; (3.) the reactor fuel cycle is to be at equilibrium with respect to the isotopic compositions in the core and blankets; (4.) a breeding ratio of at least 1.20 must be attained with a reasonable fuel doubling time; (5.) stainless steel is to be used for the fuel cladding material; (6.) the coolant outlet temperature from the reactor shall be as close to 1200°F as is achievable with stainless steel cladding, with due consideration to hot channel factors and over-power allowance. The temperature of the steam is to be 1000°F. (7.) The nominal rating of the plant is to be 1000 Mw electrical, the thermal power of the reactor is taken as 2500 Mw. (8.) The reactor design is to be optimized for minimal fuel cycle cost with consideration for the effects on capital cost. (9.) The value of plutonium is taken as $10.00 per gram of $^{239}Pu$ and $^{241}Pu$ as nitrate. (10.) The fuel reprocessing cost may be based on information in the Federal Register. The approach followed in this study was to perform first a comprehensive parameter study to determine the effects of certain variables on core performance and fuel cycle economics. On this basis, a reference conceptual design was selected. This was followed by a detailed analysis and evaluation of the reference reactor to obtain better estimates of its capability and economics. As might be expected, this analysis of the reference design pointed out areas where further improvement could be made, as for example, the zoning of the plutonium concentration in the core. It was possible to factor only some of these improvements into the design. Time limitations for the study did not permit incorporating other possible improvements such as the gap between the core and radial blankets to obtain a less positive reactivity coefficient for the voiding of the sodium in the core. A preliminary analysis of this concept indicated a significant reduction in the coefficient without materially affecting the breeding ratio. The report is presented in two volumes. Volume I contains a summary of the reactor characteristics, an evaluation of the design, a discussion of the supporting research and development programs, and a description of the reactor including drawings. Volume II contains the results of the design analysis, a description of the instrumentation and control requirements, a discussion of reactor safety, and a description of the reactor design with a gap between the core and radial blanket. (auth)

**29036** (CEND-200(Vol.II)) LIQUID METAL FAST BREEDER REACTOR DESIGN STUDY. VOLUME II. DESIGN ANALYSIS—INSTRUMENTATION, CONTROL, AND SAFETY—CORE DESIGN CHANGE TO OBTAIN A NEGATIVE SODIUM COEFFICIENT. (Combustion Engineering, Inc. Nuclear Div., Windsor, Conn.). Jan. 1964. Contract AT(11-1)-1317. 268p.

Results of the design analysis, a description of the instrumentation and control requirements, a discussion of the reactor safety, and a description of the reactor design with a gap between the core and radial blanket are presented for the conceptual design of a 1000-Mw(e) liquid-metal fast breeder reactor using PuC–UC fuel. 88 illustrations. (R.E.U.)

**29037** (GA-4512) 40-MW(E) PROTOTYPE HIGH-TEMPERATURE GAS-COOLED REACTOR. RESEARCH AND DEVELOPMENT PROGRAM. Quarterly Progress Report for the Period Ending March 31, 1963. (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Contract AT(04-2)-314. 22p.

The development of the Peach Bottom Power Reactor is discussed. Information is included on: fuel element development and testing, core loading, control rod worth, thermocouple specifications, fission product release analysis, fast neutron damage, control rod drive development and testing, fuel handling equipment testing, fission product control and distribution, and hazards analysis. (N.W.R.)

**29038** (GEAP-4418(Vol.I)) LIQUID METAL FAST BREEDER REACTOR DESIGN STUDY (1000-MWe $UO_2$–$PuO_2$ FUELED PLANT). VOLUME I. M. J. McNelly (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). Jan. 1963. Contract AT(04-3)-189. 228p.

A design study was completed for a 1000-Mw(e) sodium-cooled mixed uranium–plutonium oxide fueled fast reactor with a breeding ratio of 1.25 and sodium outlet temperature of 1100°F. The doubling time is less than 15 years. These values are consistent with the AEC objectives of a breeding ratio of approximately 1.2 and a coolant outlet temperature approaching 1200°F. A detailed description of a reference 1000-Mw(e) fast breeder reactor plant is presented together with design specifications and the ex-

perimental bases for the design. Estimates of the operating characteristics and economic performance of the reference design are given. The design was chosen after a comprehensive survey of physics and fuel design parameters. Detailed optimization was, however, not considered appropriate at this stage of development. The computational methods employed in the study are detailed and the major uncertainties and sources of error appraised. Preliminary definition of the continuing development program required to permit initiation of design of a small prototype of the 1000-Mw(e) design in 1968 for operation by 1972 is presented. All present evidence shows the reactor system to be technically feasible, although much development work remains to be completed. Further, more detailed design studies backed up by extensive hardware experience are required to define better the economic potential of the plant. A number of alternate design features or basic parameter choices that offer scope for economic performance well beyond that of the reference design are discussed. The development programs necessary to achieve this improved performance are indicated briefly. (auth)

**29039** (GEAP-4418(Vol.II)) LIQUID METAL FAST BREEDER REACTOR DESIGN STUDY (1000 MWe $UO_2$–$PuO_2$ FUELED PLANT). VOLUME II. M. J. McNelly (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). Jan. 1963. Contract AT(04-3)-189. 434p.

The design basis, development program, and future potential of fast oxide breeder reactors are presented for a conceptual design of a 1000-Mw(e) $UO_2$–$PuO_2$ fueled plant. (R.E.U.)

**29040** (GEAP-4480) SODIUM COOLED REACTORS PROGRAM. FAST CERAMIC REACTOR DEVELOPMENT PROGRAM. Ninth Quarterly Report, October–December 1963. (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). Jan. 1964. Contract AT(04-3)-189. 77p.

Vented Fuel Development. Irradiation and post-irradiation examination of a fission product release experiment capsule, containing a vented-to-coolant fuel pin, was completed. Preliminary examination and analysis of the data show a promising lack of significant activity in the sodium around the fuel pin, even when over half the stable and long lived fission gases were vented from the fuel through the sodium. A gap conductivity experiment has been initiated to determine conductivity of three different possible gap sizes which may be used in an FCR fuel. Fuel Testing in TREAT. Transient irradiation of an 0.25 inch diameter mixed oxide fuel specimen has a target peak fuel temperature, 7000°F, at which dynamic conditions due to clad rupture might be significant to the hazards analysis. Within the accident assumed (110 percent of requested power) a detailed dynamic analysis was completed indicating the transient can be performed with an adequate margin of safety. Heat transfer and physics calculations have been performed for preliminary design of a designed capsule to investigate the mode and effect of possible fuel clad rupture or penetration with high transient energy inputs. Fuel Performance Evaluation. Fabrication of large diameter fuel was completed and irradiation started in GETR. Preliminary results of out-of-pile plutonium migration experiment indicate significant and comparable diffusion of plutonium and uranium in mixed oxide. Reactor Physics and Core Analysis. Effect of the Doppler coefficient in the core disassembly process following a meltdown accident has been examined and found to reduce the energy release by factors of 10 or more. Computations confirmed that that the Pu-239 Doppler effect is virtually unchanged, as a result of overlapping of U-238 and Pul239 resonances. Specifications for a multi-group two-dimensional diffusion theory synthesis computer code have been started. (auth)

**29041** (GEAP-4606) DEVELOPMENT OF PULSED NEUTRON APPLICATION TO POWER REACTOR START-UP PROCEDURES. Seventh and Eighth Quarterly Progress Reports, October 1, 1963–March 31, 1964. E. Garelis and P. Meyer (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). Apr. 24, 1964. Contract AT(04-3)-189. 37p.

A program is being conducted to establish the feasibility of utilizing pulsed neutron techniques to measure the shutdown margin of large, thermal spectrum power reactors. In the course of this program, a new theory was suggested and an experimental apparatus was designed and built. Experiments were carried out to test the new model in the Vallecitos Thermal Critical Assembly, in the PG&E Humboldt Bay Power Reactor, and in the ESADA Vallecitos Experimental Superheat Reactor (EVESR). The experiments in the Humboldt Bay reactor were performed both prior to and following power operation. Results of these tests have been reported earlier. This present report contains additional data and information extracted from the Humboldt Bay experiments. During the last days of 1963 a number of control rod and fuel bundle worth measurements were made in the EVESR using the ($k\beta/l$) technique. A description of the experiments is given and some results are reported. A computer program was written to perform the data analysis of the pulsed neutron experiments and the code is discussed. (auth)

**29042** (GEAP-4609) HIGH POWER DENSITY DEVELOPMENT PROJECT. Sixteenth Quarterly Progress Report, January–March 1964. R. L. Holladay, comp. (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). Apr. 1, 1964. Contract AT(04-3)-361. 46p.

Failure of fuel rods in assemblies 1A, 2A, and 1F was verified by visual observations in the VBWR spent fuel storage pool. The post-irradiation examinations and tests to be performed on Task 1A and 1B fuel assemblies were outlined. Irradiation of eight Phase I developmental fuel assemblies continued in the Consumers Big Rock Point reactor. Ten Phase II development fuel assemblies containing fuel rods clad with alternate materials, Zircaloy-2, Incoloy-800, and Inconel-600, were fabricated and shipped to the Big Rock Point reactor. Poison rods containing $B_4C$ powder in Incoloy-800 tubes were fabricated for insertion into several Phase I and II developmental fuel bundles to demonstrate axial power flattening. A series of tests is being performed in the Trail Cable facility at GETR to verify the dimensional stability of thin clad, low density swaged powder fuel rods, when subjected to a 1500-psi boiling water environment. All shop work and testing was completed on the modified Instrumented Assembly for Big Rock Point. Two flowmeters were modified with graphite bearings, and loop tested. Twelve control rod oscillation tests were run at various reactor conditions during the Phase I tests at Big Rock Point. A data reduction and analysis procedure was developed which provides empirical reactor system stability data from the results of these tests; a complete reduction and analysis was made for one of the tests. The fuel bundle placement for the 84-bundle 75 Mw(e) core was specified. Calculations are underway to finalize the rod withdrawal pattern from cold shutdown to operating conditions for this core. Calculations are in progress to predict startup chamber response

during the approach to critical, for the selected withdrawal sequence. A method is being devised to allow a nodal burnout ratio calculation to be coupled to the present operating physics local peak power code. This will allow more rapid evaluation of various power distributions prior to the detailed thermal-hydraulics analysis. Physics analysis was completed on the Phase II developmental fuel assemblies, and is continuing on the reload fuel design. Preparations are under way to implement the on-line computer program for the 84-bundle core, and the Phase II tests. (auth)

**29043** (GNEC-345) ADVANCED BONUS CORE DEVELOPMENT PROGRAM. Quarterly Progress Report No. 2, February–April 1964. John F. Gibbons, Ray L. Lyerly, William A. Maxwell, and Stanley E. Turner (General Nuclear Engineering Corp., Dunedin, Fla.). May 15, 1964. Contract AT(40-1)-3154. 125p. (ORO-3154-7)

Several design configurations of the multitube fuel element were studied from a mechanical, thermal, and physics standpoint. Included were the two-pass 14-tube annular element, the two-pass 12-tube element, the one-pass 11-tube element, and a small solid element employing Zircaloy-2 as the boiler cladding material. Nuclear analysis of the ABC fuel elements in the EVESR reactor has concluded that such tests are feasible and that design confirmation can be obtained from such tests. Various core configurations were analyzed for their effect on the power split between the boiler and superheater regions, power densities, and overall maximum-to-average power ratios. Tensile tests were performed on Incoloy 800 and Inconel 625. The behavior of Inconel, Hastelloy X, SS 410, 406, 347, Gemp 16, and Inconel 600 in 1000°F $O_2$–$H_2$ was studied. Creep tests were performed on SS 406, 347, Inconel 625, and Incoloy 800 at 650 to 1200°F under 4000 to 25,000 psi. Fabrication of Zircaloy 2 collapse-clad elements, and explosive welding of Inconel 600 to Zircaloy 2 were studied. (R.E.U.)

**29044** (HW-79280(p.6.1-16)) GAS-COOLED REACTOR STUDIES. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Thermal Diffusivity Measurements of Graphite at Low Temperatures. The flash method was used to obtain thermal diffusivity data in the temperature range 25 to 600°C. Radiolysis of Carbon Monoxide. The formation of carbon suboxides from CO used as a reactor coolant is discussed. Radiation-induced Reaction of Carbon Monoxide and Water. Results of an investigation of the gamma-induced reaction of CO and water are given. Inhibition of Graphite Oxidation. A reduction in graphite oxidation rate results from the presence of $CF_2Cl_2$. Radiation Damage Exposure Units. A criterion to define exposure units for neutron radiation damage was proposed and applied to several materials. (auth)

**29045** (HW-79280(p.11.1-10)) PLUTONIUM RECYCLE TEST REACTOR OPERATION AND RELATED ACTIVITIES. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

PRTR Operation. Design Analysis and Testing. Plutonium Recycle Critical Facility (PRCR). Fuel Element Rupture Test Facility (FERTF). PRTR Support Activities: PRCF-EBWR Safety Studies; The time delay in the Doppler effect in mixed $UO_2$–$PuO_2$ with heterogeneous $PuO_2$ distribution was short enough to assure a negative temperature coefficient for periods less than prompt critical. PRTR Power Level Potential; The possibility of increasing PRTR power level is being re-examined. Fuel Reuse; Rupture Loop Connector; The zirconium content of the PRTR primary coolant is being monitored routinely as a means of detecting abnormal (fretting or impact) corrosion of Zircaloy-2. Zirconium Concentration in Primary Coolant; Development of Continuous Monitoring Procedure; Present techniques using Arsenazo, a colorimetric indicator, to determine coolant zirconium content are not sufficiently accurate because of hydrolysis or adsorption of zirconium in dilute solutions. Out-of-Reactor Fretting Corrosion Studies; Continued study of methods used to decontaminate PRTR showed that the procedure does not accelerate pitting or corrosion. Evaluation of Corrosion Effects of Decontaminants. Removal of Rupture Debris; The Oxalic-Peroxide-Peracetic solution is effective at temperatures as low as 25°C. Boiler pH Control; The use of monosodium phosphate or phosphoric acid is recommended over disodium phosphate. USAEC/AEC Cooperative Program for the Development of Heavy Water Power Reactors: Thermal Hydraulics; Fog Cooling of 19-Rod Bundles; Experiments showed that use of warts instead of wire wraps to maintain rod spacing made little difference in boiling burnout. Heated 19-Rod Bundles; Analysis of single- and two-phase pressure losses was completed. Effect of Nonuniform Heating on Boiling Burnout Dome Seal Closure Test; The dome type seal was demonstrated to be an effective closure device for reactor systems. (auth)

**29046** (HW-80284) RESEARCH AND DEVELOPMENT PROGRAMS EXECUTED FOR THE DIVISION OF REACTOR DEVELOPMENT. Quarterly Progress Report, October–December 1963. J. K. Green, ed. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Apr. 1964. Contract AT(45-1)-1350. 124p.

The programs sponsored by the Division of Reactor Development at Hanford include studies on basic properties of fuel materials and fabrication methods, physics, chemical processing of reactor fuels and radioactive waste, material development, irradiation effects on materials, fuel cycle analysis and advanced concepts, instrumentation, and nondestructive testing techniques. The results of these programs are broadly applicable to the Civilian Application Program. The report describes the progress made on these studies during October, November, December of 1963. Each section of the report covers an area of work and may include several programs. Separate abstracts were prepared for the 9 sections. (auth)

*For abstracts of individual papers see: 27279, 27751, 27857, 28044, 28088, 29002, 29047, 29048, and 29049.*

**29047** (HW-80284(p.3.1-9)) ANALYTICAL STUDIES AND ADVANCED CONCEPTS. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

Fuel cycle studies included plutonium value formulas for successive recycle, reduced density thorium fuels, and extension of fuel lifetime using plutonium and reduced density recycle. Advanced reactor studies included fueling of the Military Compact Reactor, control region studies for fast compact reactors, plant layout and fuel burnup investigations for the Fast Supercritical Pressure Power Reactor, and the development of an 18-group cross section set for large sodium-cooled fast reactors. (R.E.U.)

**29048** (HW-80284(p.6.1-10)) GAS-COOLED REACTOR STUDIES. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

The effect of the tensile load on the neutron-induced con-

traction of graphite, thermal and fast neutron detection by fission-track production in mica, and thermal oxidation of large graphite samples by water vapor are discussed. (R.E.U.)

**29049** (HW-80284(p.11.1-10)) PLUTONIUM RECYCLE TEST REACTOR OPERATION AND RELATED ACTIVITIES. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.).

PRTR operation, design analysis, and testing are discussed. PRCF–EBWR safety studies were performed for mixed oxide fuels ($PuO_2$–$UO_2$). Monitoring of the zirconium concentration in PRTR primary coolant, fretting corrosion of PRTR fuel elements out-of-pile, and decontamination after rupture of a fuel element in the IRP loop are reported. USAEC-AECL cooperative programs discussed include boiling burnout heat transfer from fog-cooled 19-rod bundles and two-phase pressure drop through pipe fittings. (R.E.U.)

**29050** (KRB-1963/3) RWE-BAYERNWERK GMBH 237 MW-KERNKRAFTWERK KRB. VIERTELJAHRESBERICHT 1963/3. (RWE-Bayernwerk GmbH 237 MW Nuclear Power Plant KRB. Third Quarter Report, 1963). (Kernkraftwerk RWE-Bayernwerk G.m.b.H., Gundremmingen, Germany). 57p.

The third quarter report on the design and construction of the 237-Mw RWE-Bayernwerk Nuclear power plant from July 1, 1963, to September 30, 1963, is presented. The construction progress made in this quarter is described in detail, and the future construction schedule is given. (J.S.R.)

**29051** (NAA-SR-6508) FINAL REPORT ON HNPF MODERATOR ELEMENT DEVELOPMENT. L. Newcomb (Atomics International Div. of North American Aviation, Inc., Canoga Park, Calif.). June 15, 1964. Contract AT-11-1-GEN-8. 57p.

The design of the moderator elements for the Hallam Nuclear Power Facility was established by testing full size prototypes under simulated operating, but nonradioactive, conditions. The test elements were subjected to a series of environmental, material, and friction tests. Analysis of the test results verified the design feasibility as well as prompting investigation of fabrication techniques. Test methods, results, and analysis thereof are presented. (auth)

**29052** (NAA-SR-9584) HNPF CONTROL SYSTEM RESPONSE DURING TRANSIENT CONDITIONS. P. F. Shaw (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). June 15, 1964. Contract AT-11-1-GEN-8. 36p.

Results of power ramps imposed on the HNPF during the month of January 1964 are documented. Analysis and evaluation of the data acquired during these tests verifies the adequacy of performance of the HNPF Plant Control System. It was demonstrated, within the conditions of the test, that the HNPF is capable of automatically following station load change rates in excess of the 5 Mw(e)/min. test objective. Data from the ramp tests and other pertinent information are included to permit independent evaluation of control system response to the imposed power ramps. (auth)

**29053** (ORNL-TM-812) STATE OF THE ART OF PRESTRESSED CONCRETE PRESSURE VESSELS FOR NUCLEAR POWER REACTORS, A CRITICAL REVIEW OF THE LITERATURE. (Franklin Inst. Labs. for Research and Development, Philadelphia) June 1964. For Oak Ridge National Lab., Tenn. Contract W-7405-eng-26, Subcontract No. 2222. 157p.

A survey of the literature on prestressed concrete pressure vessels is presented, with emphasis on areas of difficulty. Design, environmental considerations, requirements, materials, construction practices, operational control, and research and development needs are covered. In addition to 95 references, a bibliography of 166 items is included. (D.C.W.)

**29054** (ORNL-TM-832) PERFORMANCE OF PROTOTYPE EGCR FUEL AT EXTREME OPERATING CONDITIONS. M. F. Osborne, E. L. Long, Jr., and J. G. Morgan (Oak Ridge National Lab., Tenn.). May 1964. Contract [W-7405-eng-26]. 82p.

A series of experiments designed to test the EGCR fuel element concept was conducted in the ORR and the ETR reactors. The test capsules were composed of sintered $UO_2$ fuel pellets contained in stainless steel tubing. Principal test variables were fuel pellet geometry, cladding temperature, and fuel burnup. After irradiation, the capsules were examined for dimensional stability, integrity of the cladding, the fractional release of fission gas from the fuel, and any adverse interactions between the fuel and the cladding. Some of the capsules were subjected to unusual and extreme conditions of operation and many were not built within EGCR specifications. Three types of failure were observed: (1) severe cladding fractures, which were associated with high fuel temperature and impurities in the fuel; (2) microscopic cladding defects, such as void formation and intergranular separation, which were caused by localized cladding strain; and (3) failures in associated components, such as interior thermocouples and gas pressure transducers, which were included in some of the capsules. Detailed examination of these experiments revealed some of the potential problems that may be expected if EGCR fuel elements are operated outside design conditions. (auth)

**29055** (ORNL-TM-856) DESIGN AND PRELIMINARY OPERATION OF THE EGCR STEAM–GRAPHITE REACTION RATE EXPERIMENT. R. E. Helms and R. E. MacPherson (Oak Ridge National Lab., Tenn.). June 1964. Contract W-7405-eng-26. 40p.

A test facility was designed, calibrated, and put into operation for the determination of reaction rates of graphite with high pressure, high temperature steam. The facility is designed to permit exposing graphite at temperatures of 1000 to 1800°F to steam in the pressure range of 30 to 450 psig at steam flow rates up to 120 lb/hr. System calibration tests were performed, which have demonstrated the ability to measure reaction product gases quantitatively. These tests involved the introduction of carbon dioxide and hydrogen gas mixtures to the system and their subsequent recovery, measurement, and analysis for material balance purposes. Initial studies will be concerned with the reaction of steam with full-scale Experimental Gas Cooled Reactor (EGCR) fuel element graphite sleeves and with identically shaped specimens of EGCR moderator graphite. Two EGCR fuel element sleeves were tested. During these tests, several operating problems were encountered and appropriate modifications were made to the system. As presently constituted, the facility can be employed for a wide range of investigations of steam–graphite reaction rates. (auth)

**29056** (ORNL-TM-871) REVISIONS TO MSRE DESIGN DATA SHEETS, ISSUE NO. 8. R. B. Lindauer (Oak

Ridge National Lab., Tenn.). May 22, 1964. Contract W-7405-eng-26. 44p.

Revised design data sheets are presented for the Molten Salt Reactor Experiment operating at a power level of 10 Mw. This issue covers nuclear data, major components, auxiliary components and systems, and special materials. (auth)

**29057** (WAPD-BT-30(p.1-22)) A COMPARISON OF CALCULATED AND ACTUAL CONTROL ROD WITHDRAWAL TRANSIENTS AT SHIPPINGPORT ATOMIC POWER STATION. E. A. Wieczorkowski and A. I. Moss (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh).

Analog simulation was employed to calculate reactor plant response to control rod withdrawal transients. To confirm the analog calculations, tests were performed to determine actual plant response to mild rod withdrawals under controlled conditions. Calculations of power range rod withdrawal transients agree well with plant test data; however, there is less agreement in calculated and plant data for slow startup transients. An analog simulation study of core parameters indicates that discrepancies may be attributed to the effect of temperature coefficient, reactor thermal output, initial power level, and heat exchanger heat capacity employed in the simulation. (auth)

**29058** (WAPD-BT-30(p.65-79)) THE EFFECT OF CERTAIN PROCESS VARIABLES ON THE BOND QUALITY OF GAS PRESSURE BONDED PWR CORE-2 PLATE-TYPE FUEL ELEMENTS. F. O. Bingman and C. R. Woods (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh).

Several production-size PWR Core 2 plate-type fuel elements were fabricated and evaluated to establish optimum parameters to yield acceptable fuel elements by the gas pressure bonding process. Investigated here are the effects of bonding temperature, assembly clearance, and post-bonding heat-treatment on plate quality for isostatic bonding and pack bonding, two variations of the gas pressure bonding process. (auth)

**29059** (WAPD-BT-30(p.81-7)) POROSITY CONTROL IN THE MANUFACTURE OF PWR-2 SEED FUEL WAFERS. R. D. Frank (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh).

High density, uranium dioxide–zirconium dioxide, PWR Core 2 Seed 1 fuel wafers were produced with a low degree of surface and internal porosity. To maintain these qualities, visual and metallographic porosity standards were determined. Evaluation of wafers during production reduced those factors that tended to produce excessive porosity. The process controls required to maintain effective fuel wafer porosity standards are described. (auth)

**29060** (WAPD-MRP-108) PRESSURIZED WATER REACTOR (PWR) PROJECT TECHNICAL PROGRESS REPORT FOR THE PERIOD JANUARY 24, 1964 TO APRIL 23, 1964. (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Contract AT-11-1-GEN-14. 146p.

Progress on the Shippingport Pressurized Water Reactor is reported. Topics covered include: Plant modification, plant decontamination, reactor engineering, metallurgy of core materials, core operation, and reactor physics. (N.W.R.)

**29061** (WCAP-3251-1) LIQUID METAL FAST BREEDER REACTOR DESIGN STUDY. Final Report. R. B. Steck, comp. (Westinghouse Electric Corp. Atomic Power Div., Pittsburgh). Jan. 1964. Contract AT(30-1)-3251. 567p.

A conceptual design for a carbide-fuel 1000 Mw(e) fast breeder reactor has been developed that provides safe and stable operation based on a combination of inherent reactivity coefficients, a controlled expansion fuel assembly, and a modular core. This modular core design can be prototyped in existing fast reactors. The fuel cycle cost of 0.28 mills/kwh is achieved with a breeding ratio of 1.57 and a doubling time of 10.5 full-power years. The safety of the reactor is assured by a negative Doppler coefficient, a controlled expansion fuel assembly that provides a negative coefficient of reactivity, and the modular design that provides neutronics similar to a small reactor. The fuel is separated into multiple compartments to minimize the effect of fuel movement. The mixed carbide fuel is bonded by sodium to the clad, and is vented to the coolant. This design permits high heat fluxes with low fuel temperatures, release of fission gas pressure, space for fuel swelling, and does not require the neutron embrittled clad to accept large strain at the end of a 100,000 Mwd/t fuel life. This modular design is a safe design for an economic large core, and provides the important advantage that it can be prototyped in either the EBR-2 or the Fermi reactors. This would allow early testing of this design. The economics and breeding ratio are based on realistic calculations that can be brought to fruition through a development program, which, because of the modular concept, will suffice for the design of reactors from 150 to more than 5000 Mw(e). (auth)

**29062** (WCAP-3733) OPTIMIZATION STUDY FOR LARGE PRESSURIZED WATER REACTOR CORES. L. E. Strawbridge and R. E. Wolf (Westinghouse Electric Corp. Atomic Power Div., Pittsburgh). Apr. 8, 1964. Contract AT(30-1)-3064. 120p.

The basis for a core optimization study, applicable to stainless steel clad pressurized water reactors, was established. The study investigated the effects of seven variables. One group of variables corresponded to those that the reactor designer has some degree of freedom in choosing; these are water-to-uranium ratio, fuel pellet diameter, clad thickness-to-diameter ratio, and enrichment. The second group of variables was selected to investigate the effect of uncertainties in the physics calculations. The variables selected in this group were the fission product cross section, the nonthermal $^{235}U$ capture-to-fission ratio and the $^{238}U$ resonance integral. A synthetic experiment technique was employed and the values of the variables were selected to be consistent with an "orthogonal composite design." With seven variables, 143 cases were required in the study. For each case, the RENEWED code was used to determine the properties of the discharge fuel for a batch core and a 3 region out-in cycled core. In a batch core all fuel is discharged at once, whereas part of the core is discharged at a time in the cycled core. The RENEWED code uses r-z geometry and a modified one group diffusion calculation. The code performs burnup calculations and has provisions for automatic out-in cycling of the fuel. An option permits fuel costs to be calculated. After generating physics data for 143 cases using the RENEWED code, the data were fit to a general second degree polynomial in terms of the variables. The parameters which were fit for both batch and cycled cores were burnup $^{235}U$ depletion, total uranium depletion, and plutonium production. The data fitting is quite adequate, with average deviations on the order of 1% and only a few points having errors greater than 5%. The coefficients of the fitted polynomials are provided so that all of the physics information needed in a core optimization study can be readily obtained. (auth)

**29063** EXPERIMENTAL NUCLEAR POWER STATION OF LUCENS. Pierre Verstraete (EPUL, Lausanne, Switzerland). Ind. At., 8: Nos. 3-4, 55-67(1964). (In French)

The experimental nuclear power station at Lucens will be underground and equipped with a reactor moderated with heavy water and cooled with carbon dioxde. Its object is to help define a type of nuclear power station of Swiss design and to provide experience in the construction and operation of such a power station. (auth)

**29064** TRANSIENT HEAT TRANSFER IN THE CORE OF HETEROGENEOUS WATER-MODERATED WATER-COOLED BOILING REACTORS WITH NATURAL COOLANT CIRCULATION. I. P. Sergeev (Central Scientific Research Inst., USSR). Inzh. Fiz. Zh., 7: No. 3, 57-63(Mar. 1964). (In Russian)

Approximate nonlinear differential equations and some relations describing transient heat transfer in the core of a heterogeneous boiling power reactor are presented. The equations and relations are obtained by using mass, heat, and momentum balances in the form suggested for the case of a transient two-phase coolant flow. (auth)

**29065** FAST-NEUTRON FLUX MEASUREMENT OUTSIDE THE PWR PRESSURE VESSEL. G. G. Smith and F. L. Lau (Westinghouse Electric Corp., Pittsburgh). Trans. Am. Nucl. Soc., 7: 38-9(June 1964).

**29066** GAIN AND PHASE RESPONSE FOR THE VBWR IN FORCED AND NATURAL CIRCULATION. W. H. Cook, R. O. Niemi, and W. K. Wagner (General Electric Co., San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 56-8(June 1964).

**29067** A COMMENT ON THE THEORY OF NEUTRON FLUCTUATIONS IN POWER REACTORS. M. Natelson and R. K. Osborn (Univ. of Michigan, Ann Arbor). Trans. Am. Nucl. Soc., 7: 60-1(June 1964).

**29068** THE PERFORMANCE OF $B_4C$ POWDER IN THE DRESDEN CONTROL RODS. H. E. Williamson (General Electric Co., San Jose Calif.). Trans. Am. Nucl. Soc., 7: 98-9(June 1964).

**29069** COMPARATIVE PERFORMANCE OF SIMILAR ZIRCALOY- AND STAINLESS-STEEL-CLAD FUELS IN THE VBWR. H. E. Williamson, J. P. Hoffman, C. J. Baroch, and T. J. Pashos (General Electric Co., Pleasanton, Calif.). Trans. Am. Nucl. Soc., 7: 105(June 1964).

**29070** THERMAL ANALYSIS FOR GAS-COOLED REACTOR PRELIMINARY DESIGN. Lawrence A. Kimura (Aerojet-General Nucleonics, San Ramon, Calif.). Trans. Am. Nucl. Soc., 7: 145(June 1964).

**29071** DYNAMIC ANALYSIS OF COOLANT CIRCULATION IN BOILING-WATER NUCLEAR REACTORS. C. K. Sanathanan (Argonne National Lab., Ill.), J. C. Carter, and F. Miraldi, Trans. Am. Nucl. Soc., 7: 150(June 1964).

**29072** FUEL-ELEMENT-TEMPERATURE OSCILLATIONS IN THE SRE CORE II. C. L. Peckinpaugh and R. W. Keaten (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 151-2(June 1964).

**29073** COMPARATIVE FEATURES OF GAS-COOLED (HELIUM, CARBON-DIOXIDE AND SULPHUR-DIOXIDE) FAST REACTORS: SAFETY, FUELS, AND ECONOMICS. M. Bender, R. S. Carlsmith, W. R. Gall, and G. Samuels (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 7: 161(June 1964).

**29074** PHYSICS ASPECTS OF A GAS-COOLED FAST POWER REACTOR. R. T. Shanstrom (General Atomic Div., General Dynamics Corp., San Diego). Trans. Am. Nucl. Soc., 7: 162(June 1964).

**29075** THE REACTOR PHYSICS OF ADVANCED GAS-COOLED REACTORS. J. G. Tyror (United Kingdom Atomic Energy Authority, Windscale, Sellafield, Cumb., Eng.). Trans. Am. Nucl. Soc., 7: 162-3 (June 1964).

**29076** CONVERSION POTENTIAL OF A 1000-MWe HTGR USING RECYCLED FUEL. S. Jaye, D. H. Lee, H. B. Stewart, and J. R. Triplett (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Trans. Am. Nucl. Soc., 7: 163(June 1964).

**29077** METHODS OF DESIGNING COMPACT, GAS-COOLED REACTORS TO ACCOMMODATE FLOODING. Frank J. Thomas (Aerojet-General Nucleonics, San Ramon, Calif.). Trans. Am. Nucl. Soc., 7: 164(June 1964).

**29078** THERMAL ANALYSIS OF GAS-COOLED, PRESSURE-TUBE REACTORS. Peter M. Lang (Swiss Federal Inst. for Reactor Research, Wuerenlingen, AG, Switzerland). Trans. Am. Nucl. Soc., 7: 164-6(June 1964).

**29079** THE ROLE OF DISPERSED FUELS IN THE FURTHER DEVELOPMENT OF THE ADVANCED GAS-COOLED REACTOR. R. W. D'Eye (United Kingdom Atomic Energy Authroity, Risley, Lancs, Eng.). Trans. Am. Nucl. Soc., 7: 167(June 1964).

**29080** DEVELOPMENT OF STAINLESS STEEL CLADDING WITH ENHANCED DUCTILITY FOR SERVICE IN GAS-COOLED REACTORS. John H. Gittus (United Kingdom Atomic Energy Authority, Springfields, Lancs, Eng.). Trans. Am. Nucl. Soc., 7: 167-8(June 1964).

**29081** EXPERIMENTAL GAS-COOLED-REACTOR (EGCR) CHARGE MACHINE. George Gates and George Colville (Kaiser Engineers, Oakland, Calif.). Trans. Am. Nucl. Soc., 7: 169(June 1964).

**29082** STATUS REPORT ON THE PEACH BOTTOM HIGH-TEMPERATURE GAS-COOLED REACTOR. J. L. Allen (Philadelphia Electric Co.), M. R. Born, and G. R. Hopkins. Trans. Am. Nucl. Soc., 7: 169-70(June 1964).

**29083** SOME ASPECTS OF THE DRAGON HIGH-TEMPERATURE GAS-COOLED-REACTOR EXPERIMENT. A. N. Dickson (United Kingdom Atomic Energy Authority, Winfrith, Eng.). Trans. Am. Nucl. Soc., 7: 170-1(June 1964).

**29084** EBR-II WET-CRITICAL EXPERIMENTAL RESULTS. F. S. Kirn (Argonne National Lab., Idaho Falls, Idaho) and W. G. Loewenstein. Trans. Am. Nucl. Soc., 7: 172(June 1964).

**29085** FERMI APPROACH TO CRITICALITY. R. E. Mueller, C. E. Branyan, and J. B. Nims (Atomic Power Development Associates, Inc., Detroit). Trans. Am. Nucl. Soc., 7: 172-3(June 1964).

**29086** RESULTS OF ISOTHERMAL TEMPERATURE-COEFFICIENT MEASUREMENTS FOR THE ENRICO FERMI FAST BREEDER REACTOR. E. A. Fischer, R. E. Mueller, and H. A. Wilber (Atomic Power Development Associates, Inc., Detroit). Trans. Am. Nucl. Soc., 7: 174(June 1964).

**29087** SODIUM-WORTH MEASUREMENTS AND CALCULATIONS ON THE ENRICO FERMI FAST REACTOR. Ben M. Segal (Atomic Power Development Associates, Inc., Detroit), Robert E. Horn, and A. Alexanderson. Trans. Am. Nucl. Soc., 7: 174-5(June 1964).

**29088** LEAK-RATE TEST ON EXPERIMENTAL GAS-COOLED REACTOR (EGCR) CONTAINMENT SHELL.

Joseph Sherman Busch and Harvey W. Hautala (Kaiser Engineers, Oakland, Calif.). Trans. Am. Nucl. Soc., 7: 184(June 1964).

**29089** REMOTELY SEALWELDING THE PEACH BOTTOM HTGR SPENT-FUEL CONTAINERS. Gerald Bloom (AMF Atomics, Greenwich, Conn.). Trans. Am. Nucl. Soc., 7: 191(June 1964).

**29090** A GRAPHITE-COOLED RADIANT REACTOR. John J. Grebe (Dow Chemical Co., Midland, Mich.). Trans. Am. Nucl. Soc., 7: 194(June 1964).

**29091** COMPACT WATER-MODERATED PLUTONIUM BURNERS. P. L. Hofmann, G. J. Busselman, and R. H. Holeman (General Electric Co., Richland, Wash.). Trans. Am. Nucl. Soc., 7: 194-5(June 1964).

**29092** NUCLEAR CHARACTERISTICS OF SOME MOLTEN-PLUTONIUM-FUELED BREEDER SYSTEMS. W. H. Hannum (Los Alamos Scientific Lab., N. Mex.). Trans. Am. Nucl. Soc., 7: 195-6(June 1964). (LADC-6265)

**29093** THE DESIGN OF A 1000-MWe FAST-BREEDER REACTOR. C. E. Klotz (Allis-Chalmers Mfg. Co., Washington, D. C.), R. S. Miller, E. A. Fischer, J. B. Nims, R. G. Palmer, and G. R. Winders. Trans. Am. Nucl. Soc., 7: 196(June 1964).

**29094** A CONCEPTUAL DESIGN OF A 1000-MWe HIGH-TEMPERATURE GAS-COOLED REACTOR. R. M. Fryar (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Trans. Am. Nucl. Soc., 7: 196-7(June 1964).

**29095** AN OPTIMIZED CORE DESIGN FOR A 1000 MWe SODIUM/GRAPHITE REACTOR. H. Rood (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 197(June 1964).

**29096** DEVELOPMENT HORIZONS FOR THE HEAVY WATER MODERATED CONCEPT. I. N. MacKay (Canadian General Electric Co. Ltd., Toronto). 10p. (CONF-539-3)

From Canadian Nuclear Association Conference on Canada's Role in a World of Expanding Nuclear Industry, Toronto, May 1964.

The costs associated with heavy-water-moderated plants and the possibilities for cost reductions are discussed in relation, particularly, to light water systems. (D.C.W.)

**29097** OPERATING AND MAINTENANCE EXPERIENCE OF ELECTRICAL AND INSTRUMENTATION COMPONENTS AT THE SAXTON NUCLEAR POWER PLANT. D. E. Hetrick (Saxton Nuclear Experimental Corp., Saxton, Penna.). 14p. (CONF-401-3)

From Institute of Electrical and Electronics Engineers, 1964 International Convention, New York, Mar. 1964.

During the startup, checkout, and initial phases of operation of the plant, it was necessary to debug, suppress noise, and establish optimum operating conditions in the plant's electrical and instrument systems (described). In 21 months and 100,000 Mwh (thermal) of operation, only minor problems have been encountered. The performance of the systems (summarized) has been satisfactory from both the operations and maintenance standpoints. (auth)

**29098** PLANT ENGINEERING IN A SODIUM COOLED NUCLEAR POWER PLANT. J. M. Dare (Atomics International, Canoga Park, Calif.). New York, American Society of Mechanical Engineers, 1964, Paper No. 64-MPE-4, 7p, $1.00. (CONF-529-1)

From AIPE-ASME Maintenance and Plant Engineering Conference, Los Angeles, Apr. 1964.

The problems in maintenance and operation of a plant using a sodium-cooled reactor as a heat source are discussed on the basis of experience with the Hallam Nuclear Power Facility. Staff requirements are indicated. (D.C.W.)

**29099** PHYSICS OF NATURAL URANIUM—GRAPHITE POWER REACTORS. P. Bacher (Commissariat à l'Energie Atomique, Paris) and F. Minnard. 22p. (CONF-360-13)

From American Nuclear Society Topical Meeting, Nuclear Performance Power Reactor Cores, San Francisco, Sept. 1963.

Experimental and theoretical research in France on the lattice properties of graphite-natural uranium reactors with and without plutonium is summarized, together with planned research in this area. Comparisons of experimental and theoretical results are made. Control in a large reactor is discussed using EDF3 as an example; and theoretical predictions of the power distribution in EDF1 are compared with experimental values, showing the validity of the calculational methods used. (auth)

**29100** FIRST YEAR OF OPERATION OF THE ELECTRICAL EQUIPMENT IN THE BR-3 NUCLEAR POWER PLANT. L. Maesen (BR-3 Nuclear Power Plant, Mol, Belg.). 11p. (CONF-401-4)

From Institute of Electrical and Electronics Engineers, 1964 International Convention, New York, Mar. 1964.

The BR-3 plant which use a 40-Mw (thermal), closed-cycle, pressurized-water reactor began operation in December 1962. The electrical systems of the plant are briefly described, and startup tests, studies of the effect of different incidents, simulation of incidents, solutions to certain problems, and the suitability of various components are summarized. The electrical peculiarities of a nuclear plant as compared to those of a conventional plant are briefly discussed. (D.C.W.)

## Process Heat Reactors

**29101** PIPELINE GAS FROM COAL USING NUCLEAR HEAT. L. J. Pieroni, R. P. Griffin, W. H. Heffner, and G. T. Skaperdas (M. W. Kellogg Co., New York). Chem. Eng. Progr., 60: No. 6, 58-63(June 1964).

The conversion of coal into pipeline gas by nuclear heat is discussed. One possible method of utilizing nuclear energy to convert coal into pipeline gas is considered, and the economics of the method are presented. (P.C.H.)

**29102** NUCLEAR-POWERED DESALINATION OF SEA WATER FOR SOUTHERN ARIZONA. Roy G. Post and Robert L. Seale (Univ. of Arizona, Tucson). Trans. Am. Nucl. Soc., 7: 199-200(June 1964).

## Propulsion and Space

**29103** (APS-5071-R) SNAP 50/SPUR POWER SYSTEM. Annual Summary Report for Period Ending December 31, 1963. (Garrett Corp. AiResearch Mfg. Div. of Arizona, Phoenix). Jan. 31, 1964. Contract AF33 (657)-8954. 166p.

Work conducted on the Space Power Unit, Reactor (SPUR) program is described. Discussions are given of materials development and generator development. (auth)

**29104** (BAW-1263) NS SAVANNAH. Preliminary Economic Analysis. (Babcock and Wilcox Co. Atomic Energy Div., Lynchburg, Va.). Sept. 1962. Contract AT(30-3)-274. 26p.

Includes Appendices A and B.

Economic aspects of the NS Savannah design are discussed. An estimated capital cost summary for duplica-

tion of NS Savannah is presented. NMSR fuel cost summary calculations are given. (R.E.U.)

**29105** (IDO-16929(Rev.1)) SAFETY ANALYSIS REPORT—SNAPTRAN 2/10A-3 WATER IMMERSION TESTS. F. W. Ahrens, F. L. Bentzen, G. F. Brockett, D. T. Jones, L. I. Moss, W. J. Neal, J. M. Waage, T. R. Wilson, and W. L. Wilson (Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho). Mar. 1964. Contract AT(10-1)-205. 128p.

A series of experiments will be conducted to evaluate the hazards associated with the use of the SNAP 2/10A reactors. The SNAPTRAN 2/10A-3 series is directed toward a determination of the consequences of a nuclear accident approaching the maximum credible which would result from the immersion of a SNAP 2/10A reactor core in water. This simulated accident, which is expected to completely destroy the reactor core by a nuclear excursion, will be preceded by static physics measurements and a few long-period transient tests. The potential hazards associated with conducting the SNAPTRAN 2/10A-3 program have been evaluated and are presented. Given are a description of the experimental program, a description of the reactor test package and control system, a discussion of the results of previous water immersion experiments, a discussion of the operating philosophy and test procedures, and an evaluation of the potential hazards attendant to the experimental program. The areas of consideration in the safety evaluation include materials handling, possible operator error and system failure, radiation levels associated with the various tests, and consequences of the maximum nuclear excursion. On the basis of the safety analysis conducted, it is concluded that the test program can be conducted without undue hazard to operating personnel, other personnel within the NRTS, or the general public. (auth)

**29106** (LAMS-2968) INVESTIGATION OF COUPLED ROVER CORES. R. L. Seale (Los Alamos Scientific Lab., N. Mex.). Feb. 1964. Contract W-7405-eng-36. 32p.

The effect of operating four Rover reactors in a clustered array was investigated in an attempt to establish the extent of the interaction at zero power between the individual cores in the array and to identify any fundamental limitation that may compromise such operation. The study of the static behavior of the array shows that the average flux level in each core is strongly influenced by the relative reactivity setting of that core. This implies that the performance of each core in the array should be monitored individually. The kinetic analysis indicates that there are no neutronic induced resonances in the system for the values of coupling parameters of interest in Rover type systems. There appear to be no fundamental limitations imposed by neutronics in the operation of coupled arrays at zero power. Further study of kinetics of operation at high power where reactivity is flux- (and temperature) dependent is recommended. (auth)

**29107** (NAA-SR-9715) APPLICATION OF SNAP REACTOR POWER SYSTEMS TO MANNED SPACE STATIONS. (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). June 15, 1964. Contract AT-11-1-GEN-8. 116p.

Manned space laboratories and stations are an integral part of the National Space Program and are currently in the planning phases within both NASA and the USAF. These laboratories and stations will require sizeable amounts of on-board electric power to perform their life-support, guidance and control, communications, and operational functions. Nuclear power systems currently under development in the USAEC's SNAP Program offer many advantages as prime power sources for these laboratories and stations, i.e., a high power-to-weight ratio, low radiator areas and therefore low drag and minimum propellent inventory for station keeping in low earth orbit (150 to 350 n-mi), no effect on power production during the sunshade orbital transient, no complex sun orientation required during the sun portion of the orbit, etc. The SNAP nuclear power system that appears to offer the most potential for these applications in the 5 kw to few hundred kw power range with lifetimes greater than several weeks, is the zirconium-hydride-uranium thermal reactor coupled through a NaK loop to a Mercury-Rankine Power Conversion System. This system is currently under development by the USAEC and could be qualified and ready for use during the 1970 to 1980 time period. Preliminary designs of this system at 5, 10, 15, and 20 kw(e) power levels give unshielded system weights (including one redundant power conversion system) of 1850, 2530, 3230, and 3940 lb, respectively. Shielding for 90-day on-orbit stay time in a 10-ft-diameter space station results in total plant weight for these power levels of 4310, 5040, 5760, and 6470 lb. (auth)

**29108** (SC-DC-64-855) RE-ENTRY FLIGHT DEMONSTRATION NUMBER TWO (RFD-2). (Sandia Corp., Albuquerque, N. Mex.). May 1964. Contract AT(29-1)-789. 13p.

RFD-2 is the second in a series of tests which are expected to advance technology in the area of re-entry burnup as applied to aerospace nuclear safety. The first test, RFD-1 (NSA, 18: 4836), was a re-entry burnup study of a nuclear reactor (SNAP-10A), whereas RFD-2 is concerned with an inert simulation of an isotopic generator. Data from the flight will be used to predict the re-entry burnup of isotopic generators and to improve theoretical mathematical models used for burnup calculations. Experimental data from both flights will be used to refine existing computer heat transfer codes, thereby providing better burnup predictions for future applications. After data from both tests have been correlated, the resulting information will be used to design future flight tests which will further advance knowledge in the areas of re-entry burnup and nuclear safety. (auth)

**29109** REACTOR PHYSICS OF NUCLEAR ROCKET REACTORS. R. K. Plebuch and K. F. Hansen (Massachusetts Inst. of Tech., Cambridge). Trans. Am. Nucl. Soc., 7: 63-4(June 1964).

**29110** THE NERVA NEUTRON ENVIRONMENT AS AFFECTED BY THE ANGULAR DISTRIBUTION OF NEUTRON LEAKAGE. W. R. Butler and J. A. Vreeland (Aerojet-General Nucleonics, Azusa, Calif.). Trans. Am. Nucl. Soc., 7: 65-6(June 1964).

**29111** INVESTIGATION OF A ROCKET FUEL TEST REACTOR (RFTR). Donald R. MacFarlane and John T. Madell (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 68-9(June 1964).

**29112** ANALYSIS OF SNAP-8 AUTOMATIC STARTUP. Samuel Birken and Charles J. Code, Jr. (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 129(June 1964).

**29113** S8ER OPERATING EXPERIENCE. V. L. Rooney and J. Marvosh (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 129-30(June 1964).

**29114** QUALIFYING THE SNAP-10A CONTROL AND REFLECTOR ASSEMBLY. Richard A. Johnson (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 130-1(June 1964).

**29115** THERMAL MODEL OF A SNAP REACTOR CORE WITH FLOWING COOLANT. R. W. Winson (Atomics International, Canoga Park, Calif.). Trans. Am. Nucl. Soc., 7: 152-3(June 1964).

**29116** LEAK TESTING THE N. S. SAVANNAH CONTAINMENT VESSEL. J. H. Taylor (N. S. Savannah Technical Staff, Galveston, Tex.). Trans. Am. Nucl. Soc., 7: 186-7(June 1964).

**29117** RELIABILITY AS A CRITERION IN NUCLEAR SPACE POWERPLANT DESIGN. Arthur P. Fraas (Oak Ridge National Lab., Tenn.). New York, Society of Automotive Engineers, Inc., and New York, American Society of Mechanical Engineers, 1964, Paper No. 861A, 8p. $1.00. (CONF-505-7)

From Society of Automotive Engineers Air Transport and Space Meeting, New York, Apr. 1964.

The design of nuclear power plants for space applications is complicated by the lack of reliability data. Analogous operating data on 14 turbine-generator units are described; equations and illustrations are presented to illustrate the data. Material compatibility; system integrity and the means to achieve it; problems encountered with moving parts; and the reliability of electronic components are discussed in relation to system design. It is concluded that as simple a system as possible with a minimum number of components is necessary to attain a high degree of system reliability. Furthermore, an exceptionally high level of engineering competence will be required, and design philosophy will have to differ greatly from that presently used for other types of powerplants. (auth)

**29118** IMPROVEMENTS IN OR RELATING TO NUCLEAR REACTORS. (to Allis-Chalmers Mfg. Co.). British Patent 961,234. June 17, 1964. Priority date Jan. 5, 1961, United States.

A nuclear power reactor is designed for propulsion of mobile units, particularly submarine vessels in which head room is limited. The reactor core comprises a shroud stack of long hollow fuel elements with their longitudinal axis arranged horizontally, the pressure vessel is a cylinder lying on its side, and the control rods likewise are reciprocal endwise of the pressure vessel. Thus, the head room required is reduced. (D.L.C.)

## Research and Test Reactors

*Refer also to abstract 27922.*

**29119** (AEET/ROD/5) WATER CHEMISTRY IN CANADA INDIA REACTOR. V. Surya Rao, D. G. Vartak, and S. M. Sundaram (India. Atomic Energy Establishment, Trombay). 1963. 15p. (CONF-243-56)

From American Nuclear Society Conference on Problems of Operating Research and Power Reactors, Ottawa, Oct. 1963.

The problem of blocked coolant water channels in the Canada India 40-Mw(t) reactor is discussed. The problem was solved by using demineralized and sterilized water in conjunction with a bypass ion exchange system. Control of the silica and oxygen contents in the water is discussed. (D.L.C.)

**29120** (AID-Report-P-63-103) SOVIET RESEARCH REACTOR RFT. Summary of Data. (Library of Congress. Aerospace Information Div., Washington, D. C.). Aug. 2, 1963. 14p. (AD-415355)

A detailed description of the RFT reactor is presented which includes background information, design features, reactor parameters, and experimental facilities. The reactor operation and experiments are also described. (D.L.C.)

**29121** (DOFL-TR-1104) NEUTRON AND GAMMA MEASUREMENTS. MARK I AND MARK F TRIGA REACTORS. Philip G. Berman (Harry Diamond Labs., Washington, D. C.). Apr. 30, 1963. 68p.

Integrated neutron-flux (fluence) and neutron-spectrum data were obtained on the Triga Mark I and Mark F reactors. Limited gamma-ray dose data were also obtained. The data are presented graphically to facilitate determination of the radiation environment provided at the various test positions in the reactors. Gamma-ray doses were as high as 145,000 r/pulse; and neutron fluence above sulfur threshold (3 Mev) was greater than $10^{14}$ n/cm$^2$. (auth)

**29122** (ORNL-3578(p.96-9)) REACTOR INSTRUMENTATION AND CONTROLS SYSTEMS ENGINEERING. (Oak Ridge National Lab., Tenn.).

The Health Physics Research Reactor has been installed and operated in its permanent location at ORNL after having been checked at the ORNL Critical Facility and operated at the Nevada Test Site. Each of these phases of operation is discussed. Design of the MSRE instrumentation and control system was continued. Requirements for the nuclear and safety systems were determined. Procurement of process instrumentation is nearing completion and procurement of nuclear instrumentation is under way. Installation of equipment at the reactor site was begun. The types and cost of instrumentation installed in the large GCR Loop No. 2 in-pile experiment in ORR are discussed. (auth)

**29123** (ORNL-TM-810) A FEASIBILITY STUDY OF OPERATING THE BSR-I AT 1 MW ON A 16-HR-DAY SCHEDULE. J. D. Kington and J. Miller (Oak Ridge National Lab., Tenn.). May 25, 1964. Contract W-7405-eng-26. 6p.

Tests were made to determine whether the BSR-I could be operated on a 16-hr-day schedule at a power level of 1 Mw. The study showed that the excess reactivity is sufficient for 1-Mw operation on this schedule and that during the winter the maximum allowable pool temperature of 50°C would not be exceeded. The pool-side radiation level would be undesirably high but not unmanageable. In order to operate the reactor the year around at 1 Mw on the 16-hr-day basis, a forced-convection cooling system with a holdup tank and degasifier should be installed; this would also greatly reduce the radioactivity level. (auth)

**29124** EQUIPMENT FOR AUTOMATIC CONTROL OF THE NUCLEAR REACTORS ARGUS AND ARBI. A. Díez, P. Pezuela, A. Tanarro, and F. González (Junta de Energia Nuclear, Madrid). Anales Real Soc. Espan. Fis. Quim. (Madrid), Ser. A, 59: 199-212(Sept.-Oct. 1963). (In Spanish)

An automatic control channel for Argonaut-type reactors is described. It is designed to hold the reactor power constant at any preset level between 1 and $10^{-3}$ maximum power. Construction details of the equipment are given. Stability analysis and safety considerations are also included. (auth)

**29125** THE SCOTTISH RESEARCH REACTOR CENTRE. J. M. A. Lenihan (Western Regional Hospital Board, Glasgow). Contemp. Phys., 5: 212-16(Feb. 1964).

Proposals leading to the construction of the reactor are described. The design of the reactor, an enriched-uranium fuel, water-cooled, graphite-moderated reactor based on ANL's Argonaut Reactor, is surveyed briefly. (M.J.T.)

**29126** USE OF NUCLEAR REACTORS FOR BIOLOGICAL RESEARCH, AND FOR MEDICAL USES. C. Arghittu (Centro Applicazioni Militari Energia Nucleare, S. Piero a Grado, Italy). Minerva Nucl., 8: 42-61(Jan.-Feb. 1964). (In Italian)

Various types of nuclear reactors used for biological research and in the treatment of tumors are described. The techniacl characteristics of the different types of reactor are discussed, especially with regard to the possibility of neutron irradiation of tumors, the production of short-lived radioisotopes, and analysis by activation. (auth)

**29127** FUEL ELEMENTS FOR THE ADVANCED TRIGA-MARK III PULSING REACTOR. M. T. Simnad, G. Hopkins, and J. Shoptaugh (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Trans. Am. Nucl. Soc., 7: 110(June 1964).

**29128** DESIGN AND DEVELOPMENT OF AN EXCURSION-LIMITING FUSE FOR THE MIXED-SPECTRUM CRITICAL ASSEMBLY. G. Brynsvold, K. Hikido, and Hugh F. Johnston (General Electric Co., San Jose, Calif.). Trans. Am. Nucl. Soc., 7: 136-7(June 1964).

**29129** SPERT I EXPERIMENTAL INVESTIGATIONS OF POTENTIALLY DESTRUCTIVE REACTIVITY ADDITIONS TO AN OXIDE CORE. J. E. Grund (Phillips Petroleum Co., Idaho Falls, Idaho). Trans. Am. Nucl. Soc., 7: 140(June 1964).

**29130** THE FAST REACTOR TEST FACILITY. Norman J. Swanson, Orville S. Seim, and Julius D. Geier (Argonne National Lab., Ill.). Trans. Am. Nucl. Soc., 7: 175-6(June 1964).

**29131** COMBINED $S_N$ AND DIFFUSION CALCULATIONS OF ZPR-III AND OTHER FAST REACTORS. A. Halim Kazi (United Nuclear Corp., White Plains, N. Y.). Trans. Am. Nucl. Soc., 7: 176-7(June 1964).

**29132** ACCELERATOR-PULSED FAST ASSEMBLY. J. L. Russell, Jr. (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Trans. Am. Nucl. Soc., 7: 178-9(June 1964).

**29133** RESULTS OF INNOVATIONS IN LEAK-RATE TESTS AT THE NASA PLUM BROOK REACTOR. E. G. Keshock, C. E. DeBogden, and J. Atkinson (Lewis Research Center, Cleveland). Trans. Am. Nucl. Soc., 7: 185-6(June 1964).

**29134** FUEL ARRANGEMENT FOR A NEUTRONIC TEST REACTOR. Erling Frisch and Mortimer A. Schultz (to Westinghouse Electric Corp.). U. S. Patent 3,138,534. June 23, 1964. Filed Sept. 6, 1960.

A fuel element is designed with means for supporting specimens to be irradiated, in regions of maximum neutron flux density. The fuel element comprises a plurality of concentric fuel tubes of varying diameter, and the test specimens are located in a holder in the central passage of the element. The specimen holder is designed with a nozzle so shaped that handling tools can be used for placement of the fuel element and holder. (D.L.C.)

# WASTE DISPOSAL AND PROCESSING

**29135** (DP-844) STORAGE OF RADIOACTIVE WASTES IN BASEMENT ROCK BENEATH THE SAVANNAH RIVER PLANT. R. J. Christl— F. H. Springer, ed. (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). Mar. 1964. Contract AT(07-2)-1. 103p.

The ground beneath a three-square-mile area of the Savannah River Plant was explored to determine the attitude, continuity, types, and character of the basement rock; the hydrology of the basement rock; and the hydrology and character of the overburden. These studies show that radioactive waste solutions can be stored safely in the basement rock beneath the Savannah River Plant. A conceptual design was developed for constructing a 20,000,000-gallon, or larger, storage facility 1300 to 1700 feet beneath the ground. (auth)

**29136** (HW-79762(Pt.2)) SOLVENT EXTRACTION OF STRONTIUM, CERIUM, AND RARE EARTHS WITH D2EHPA. PART 2. PILOT PLANT STUDIES. G. L. Richardson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Feb. 1964. Contract AT (45-1)-1350. 48p.

A four-column D2EHPA process was developed for the simultaneous extraction of Sr and rare earths from Purex acid waste (PAW). The clarified PAW, with added citric or tartaric acid, is adjusted to pH 4.7 and contacted with 0.2 M D2EHPA–0.2 M TBP–hydrocarbon diluent. The solvent, containing only Sr, rare earths, Ca, and Na, has its Na stripped by formic acid, its Sr stripped by dilute $HNO_3$, and its rare earths and Ca stripped by more concentrated $HNO_3$. The spent solvent is then washed with a basic solution to remove Y and "irreversibly" extracted metals. Typical process performance is given. Temperature has a pronounced effect on Ce extraction in the first column. A total extraction concept was also tested with a stored alkaline sludge dissolved in $HNO_3$. The major limitation to this process was the difficulty of producing a stable feed at the desired pH without an expensive complexing agent. (D.L.C.)

**29137** (IDO-14622) A COMPARISON OF VARIOUS CALCINATION PROCESSES FOR PROCESSING HIGH-LEVEL RADIOACTIVE WASTES. B. R. Wheeler, J. A. Buckham, and J. A. McBride (Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho). Apr. 1964. Contract AT(10-1)-205. 76p.

Published information and data relative to the four principal radioactive waste calcination techniques, the fluidized bed, the pot, the radiant-heat spray, and the rotary-ball kiln are summarized on a comparative basis. An ultimate combined capacity of about 1000 gph is expected to be necessary to process generated and accumulated wastes between the years 1965 and 2000. The effects on product properties and on economics of ultimate waste disposal of the type of calciner selected are considered from many standpoints, including the composition, concentration, and activity level of the waste solution and the calcination conditions. Also discussed are creation of glass-like compounds from calciner products, personnel and equipment requirements, and the present status of development of each of the calciners. One or more calciners may be suitable to process any particular waste, depending on the desired type of product and other circumstances. (auth)

**29138** (IDO-14629) DEVELOPMENT OF AIR DISTRIBUTOR CAPS FOR A FLUIDIZED BED. J. C. Petrie and D. E. Black (Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho). Apr. 1964. Contract AT(10-1)-205. 20p.

Results are presented of a pilot plant study of factors which affect erosion and performance of caps installed on an air distributor plate in a fluidized bed calciner. The study was initiated because of the excessive erosion experienced on the original air distributor caps installed in the calciner vessel at the ICPP Waste Calcining Facility. Laboratory techniques which considerably reduce the time required to obtain erosion data in tests are described. A theoretical orifice formula is given which accurately predicts the pressure differential across the geometrically complex orifices in the air distributor plate. Details are given of the air distributor cap selected for use in radioactive operation of the Waste Calcining Facility as a result of these tests. (auth)

**29139** (ORNL-TM-839) CALCINER POT FOR LIQUID WASTE CALCINATION PROGRAM. Design Report. R. M. Beckers (Oak Ridge National Lab., Tenn.). Apr. 17, 1964. Contract W-7405-eng-26. 3p.

Criteria and assumptions used in design calculations for a 8-in. 304L stainless steel calciner pot are presented. Estimates of the rupture strength of the shell under various conditions are presented. Five engineering drawings are available as CAPE-1150. (M.C.G.)

**29140** (ORNL-tr-143) TREATMENT OF RADIOACTIVE EFFLUENTS AT THE ENRICO FERMI NUCLEAR RESEARCH CENTER OF THE MILAN POLYTECHNIC INSTITUTE. Alessandro Facchini. Translated for Oak Ridge National Lab., Tenn., from Acqua Ind., Nos. 7-8(May-Aug. 1960). 22p.

The radioactive waste treatment methods used at the E. Fermi Nuclear Center of the Milan Politecnico are presented. The liquid wastes are concentrated by evaporation in an evaporator which is described; the combustible solid wastes are incinerated and the gas is filtered. (auth)

**29141** ON THE TREATMENT OF LIQUID WASTE PRODUCED BY ORGANIC COOLED AND MODERATED REACTORS. G. Branca and S. Gagliardi (CNEN, Rome). Ing. Sanit., No. 6, 2-8(1962). (In Italian)

The contaminated liquid wastes produced by an organic moderated and cooled reactor and its ancillary devices can be divided into two types: organic and aqueous. More specifically, the wastes of the second type consist of the condensation waters of the ejectors of the degassing and purification plants and the waters eliminated by the decontamination systems. The main features of such wastes are examined, with reference to a possible negative influence on the disposal of the radioactive substances. The results of a series of tests performed to ascertain which treatment is more adequate for these wastes are presented. (auth)

**29142** HANDLING AND BURYING OF RADIOACTIVE WASTES IN HUNGARY. Daniel Voedroes (Fővárosi Közegészségügyi Állomás, Budapest). Nepegeszsegugy, 42: 315-18(Oct. 1961). (In Hungarian)

The proper disposition of radioactive lab wastes is discussed, and practices and procedures laid down by the

Ministry of Health are outlined. It is pointed out that radioactive wastes should be separated from other ordinary waste material and deposited in special containers. The contaminated wastes should be separated as to types of isotope contamination and whether they can be incinerated or not. Contaminated wastes which have a radioactive half life of less than 30 days can be stored at the lab site, and, after proper checks and measurements, can be disposed of with ordinary refuse. Contaminated clothing should be labeled and stored in a shielded area, and after the necessary decontamination time, can be reused. Contaminated wastes having a half life of 30 days to five years should be stored separately and liquid wastes should be placed in glass or polyethylene containers, which are then placed in a metal container to avoid spills in case of breakage. Long-term wastes, those having a half life of five years or longer, should be stored separately. Wastes contaminated by $^{14}C$ should always be stored separately. Radioactive wastes of all types should be dated and labeled as to type of isotope causing contamination, circumstances of contamination, the isotope's chemical characteristics, total activity, and solvents present. Various methods of concentrating the wastes, such as incineration and subsequent storage of ashes, are also discussed. Boiling down, silting, and sealing certain isotopes in concrete are discussed as alternative possibilities. (BBB)

# GENERAL AND MISCELLANEOUS

**29143** (ANL-6743) SOME APPLICATIONS OF SCINTILLATION SPECTROMETRY TO NONDESTRUCTIVE TESTING. Ronald B. Perry (Argonne National Lab., Ill.). Mar. 1964. Contract W-31-109-eng-38. 13p.

Gamma-ray scintillation spectrometry is a useful tool for the nondestructive assay of the $^{235}U$ content of research reactor fuel. The $^{235}U$ is the only isotope of uranium that produces a strong peak of gamma energy at 184 kev. Accordingly, the $^{235}U$ content of reactor fuel can be accurately determined by counting the 184-kev gamma emission. Uranium foil standards of known weight and isotopic content can be used for assay of fabricated reactor fuel with a product of density and thickness small enough to permit accurate measurement of the self-absorption factor. Two techniques for nondestructive assay of fabricated fuel in flat configurations, based on the use of uranium foils as standards, are discussed. In the first method a small area is counted and homogeneity is assumed. In the second method, a two-dimensional scanning technique is employed such that the entire sample is counted. A similar scanning technique has been used for tubes of 5.08- to 7.62-cm diameter. Other configurations of reactor fuel have products of density and thickness or geometrical shapes that do not permit accurate measurement of the self-absorption factor for the 184-kev gamma. Standard samples for these configurations may be taken from the material itself and standardized by mass-spectrometric and chemical analysis or specially fabricated from material of known $^{235}U$ content. Scintillation counting techniques may be applied to other reactor fuel testing problems. Distribution of $^{235}U$ in dispersion and alloy-type fuels can be measured by counting small areas with a well-collimated detector. (auth)

**29144** (HW-75715) DATA AND METHODS EMPLOYED IN UPDATING THE R. B. U. BASIC LIBRARY. R. C. Liikala (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Dec. 20, 1963. Contract AT(45-1)-1350. 56p.

References to the nuclear data utilized in updating certain nuclides in the R. B. U. Basic Library (NSA, 17: 41860-62) are given. A brief description is also given as to the methods employed in generating and evaluating these data. (auth)

**29145** (MLM-1185) MOUND LABORATORY PROGRESS REPORT FOR FEBRUARY 1964. J. F. Eichelberger, G. R. Grove, and L. V. Jones (Mound Lab., Miamisburg, Ohio). Feb. 28, 1964. Contract AT(33-1)-Gen-53. 30p.

Radioelements. Operations are being conducted for separating and purifying uranium-234 from aged plutonium-238 solutions by a combination of ion exchange and solvent extraction techniques. Two aged plutonium samples were processed and 84 mg of uranium-234 were recovered. A third source containing two grams of uranium-234 is being processed. In the first two anion exchange runs, the uranium recovery was 40 to 50%. A method for the determination of uranium in the presence of plutonium, iron, and aluminum was developed. The polonium-210 content of cigarettes and pipe tobacco was determined to be 0.30 picocuries ($10^{-12}$ curie) per gram, in good agreement with recently reported values. The polonium-210 probably results from decay of naturally occurring uranium-238 and radium-226. The half-life of polonium-209 was determined by the alpha-activity ratio of polonium-208 to polonium-209 as a function of time in a sample containing both isotopes. The half-life was found to be 42.4 ± 6.0 years, in fair agreement with the previously reported value of 40.2 ± 2.6 years. The half-life of the metastable state at 0.305 Mev in arsenic-75 was determined by a coincidence method to be 15.64 ± 0.92 msec. The same coincidence technique was used in an unsuccessful attempt to detect a metastable state at 1.42 Mev in bismuth-208, which may be populated in the electron-capture decay of polonium-208. From a study of the alpha-gamma coincidence spectrum of polonium-208 and polonium-209, two additional alpha groups were tentatively established at 4.62 and 4.78 Mev. Difficulty is still being experienced in preparing a barium-140 stock solution free of calcium. The results of treating alpha-counting data by two different computational methods are compared with the calorimetric results. The computed values are found to be in good agreement. The viscosity of a molten plutonium-one weight % gallium alloy was measured at 12 temperatures from its 669°C liquidus temperature to 816°C. The viscosity decreased from 8.82 centipoise at the liquidus temperature to 6.60 centipoise. The one weight % addition of gallium to plutonium raised the viscosity an average of 50% as compared to unalloyed molten plutonium in the same temperature interval. Alpha and Neutron Sources. The increase in the neutron flux of plutonium–beryllium sources due to the ingrowth of americium-241 is being measured. Isotope Separation. Using the 11-column thermal diffusion column cascade a production rate of 0.6 gram carbon-13 per month was established. A rigorous theory of a thermal diffusion column is being developed. The dependence of the coefficient of viscosity ($\eta$), thermal conductivity ($\lambda$), and density ($\rho$) on the composition of the isotopic mixture, which was neglected in the Jones and Furry theory, is being taken into account. The revised theory allows for a variation in wire temperature, a phenomena which has been observed experimentally and which arises because of the concentration dependence of the thermal conductivity. Plastics and Adhesives Research. Heat resistant, epoxy foam formulations were evaluated. One formulation was superior in solvent resistance and compressive strength, but was not as resistant to heat as one of the other formulations. Three manganese dioxide-cured, polysulfide-based conductive adhesives were prepared and evaluated. The electrical resistivities of the formulations ranged between 0.05 and 0.06 ohm-cm; tensile bond strengths ranged between 280 and 300 psi, and peel strengths ranged between six and seven pounds per inch. Films of the formulations had an ultimate elongation between 1- and 11% at −65°F. Substitution of polysulfide prepolymer LP-3 and LP-33 in these formulations did not appreciably change their handling properties. The silicone potting compound, LTV-602, was reinvestigated as a base for conductive adhesives. All formulations had low peel strengths of about 0.5 pounds per inch. The electrical resistivities of these formulations increased on aging. These were the most flexible materials at −65°F tested to date. Analytical. The construction of Calorimeter 91 was completed and tested. Calorimeter 91 is an automated precise twin-bridge calorimeter designed to accurately assay radioactive materials. (auth)

**29146** (MLM-1192) MOUND LABORATORY PROGRESS REPORT FOR MARCH 1964. J. F. Eichelberger,

G. R. Grove, and L. V. Jones (Mound Lab., Miamisburg, Ohio). Mar. 31, 1964. Contract AT(33-1)-Gen-53. 28p.

Radioelements. $^{234}U$ was recovered from two aged $^{238}Pu$ solutions by anion exchange and solvent extraction. Isotope Separation. Progress is reported for the determination of the thermomolecular pressure gradient of $^{3}He$ and $^{4}He$ in the development of $^{3}He$ vapor pressure thermometry. The production of $^{13}C$-enriched methane in an 11-column thermal diffusion cascade is described. The separation of Ne isotopes in the one-one overlap thermal diffusion system and the two-column thermal diffusion cascade is also described. The performance of the hot calcium purification system for argon cleanup in argon separation is given. Results of four runs in the chromatographic separation of Kr from Xe are given. A theory for the thermal diffusion column is being developed. Data are given for Ne isotope separation in a thermal diffusion column with a d-c-heated center wire. A reversible magnetic circulating pump was designed. A study is being made of the burning out of center wires in thermal diffusion columns. Plastics. The effects of silane coupling agents on the physical properties of standard asbestos-filled diallyl phthalate formulations were determined. Several epoxy foam evaluations were made, and gel times, exotherms, and heat resistances are reported. Analytical. An automatic sample loading device for a calorimeter was developed for unattended assays. The 2.2-Mev gamma ray from neutron capture by hydrogen in water was observed. An aged $AcF_3$ sample is being counted to determine the $^{22}Na$ resulting from the $^{19}F(\alpha,n)$ reaction. (D.L.C.)

**29147** (NASA-SP-41(p.273-303)) PROBLEMS RELATED TO COMPATIBILITY TESTING. A. HEAT TRANSFER AND FLUID FLOW (HYDRODYNAMIC AND THERMAL INFLUENCES IN CORROSION STUDIES). H. W. Hoffman (Oak Ridge National Lab., Tenn.).

A treatment is presented of the influence of heat transfer and fluid mechanics on dynamic corrosion. Some aspects of the hydrodynamic problems are illustrated by a description of a number of studies. These studies include surface shear and boundary-layer flow in the corrosion of type 347 stainless steel by uranyl sulfate solutions, effects of thermal oscillations on the corrosion resistance of Inconel to fused $NaF-ZrF_4-UF_4$, and flow and temperature phenomena in boiling potassium. (D.L.C.)

**29148** (NP-13994) LITERATURHINWEISE ZU RECHTS- UND WIRTSCHAFTS-FRAGEN DER ATOMENERGIE DER RAKETENTECHNIK DER WELTRAUMFAHRT. NR. 10. ZUGÄNGE DER WISSENSCHAFTLICHEN SAMMLUNGEN IN DER ARBEITSSTELLE FUR TECHNOLOGISCHE DOKUMENTATION (1.9.1963-31.3.1964). (Literature Search on Legal and Economic Questions of Atomic Energy, Rocket Technology, and Space Travel. No. 10. Access for Scientific Collection in the Working Group for Technical Documentation, September 1, 1963-March 31, 1964). (Kernforschungsanlage, Jülich, Germany). Apr. 1964. 60p.

Approximately 300 references on legal and economic questions of atomic energy, rocket technology, and space travel are presented. They are arranged by subject and under that by author or corporate author. (M.C.G.)

**29149** (NYO-3034-1) STUDIES OF PHOTOINDUCED ELECTRODE POTENTIALS. Final Report. (Juniata Coll., Huntingdon, Penna.). [nd]. Contract AT(30-1)-3034. 10p.

Three aspects of photopotentials were studied. First, considerable work was done in an attempt to establish the kinetics of photopotential production and to relate this to the photochemical mechanism of a known system. Second, the anthraquinone system was investigated in considerable detail, both under conditions where the 9, 10-dihydroxyanthracene is formed as a reduction product and those conditions where the anthraquinone semi-quinone radical is formed. Third, the photolysis of benzophenone was investigated. (N.W.R.)

**29150** (SC-DC-64-765) ON THE ANISOTROPIC MECHANICAL PROPERTIES OF STRUCTURAL ALUMINUM ALLOYS. Final Report. L. J. Demer, A. W. Stephens, and C. G. Valenzuela (Arizona. Univ., Tucson. Coll. of Mines). Mar. 1964. For Sandia Corp., Albuquerque, N. Mex. Contract AT(29-1)-789. 67p.

The report of this investigation is divided into three phases. The first phase is concerned with the effect of deformation temperature on the texture and mechanical anisotropy of rolled high-purity aluminum. Texture was investigated by means of quantitative pole figures and the mechanical anisotropy was evaluated by microhardness testing and tensile property determination as a function of angle to the rolling direction. Change in rolling temperature caused a marked transition in the texture and affected the mechanical anisotropy detected both by microhardness and by tensile property determinations. The second phase is concerned with the effect of thermal treatment on the texture present in a $\frac{3}{4}$-in. plate of 7178-T651 aluminum alloy plate as received from the producer. The texture present after application of an ALCOA T6 heat treatment to a sample in the as-received condition is compared with that present in the original material. Microhardness anisotropy was determined in both of the above conditions and also after application of an interrupted-aging treatment to the as-received material. Differences in the resulting values attest to the difference in texture present in the material in these three conditions. The last phase of the study is concerned with detailed investigation of a number of experimental procedures and conditions involved in the determination of pole figures. Recommendations are made for obtaining accurate pole figures of aluminum using the GE pole-figure goniometer. (auth)

**29151** (SC-DC-64-890) RESEARCH ON PIEZOELECTRIC MATERIALS AND PHENOMENA. Annual Progress Report, January 1, 1963-December 31, 1963. D. A. Berlincourt and H. H. A. Krueger (Clevite Corp. Electronic Research Div., Cleveland). Mar. 16, 1964. For Sandia Corp., Albuquerque, N. Mex. Contract AT(29-1)-789. 221p.

Compositions in the $Pb(Zr,Sn,Ti)O_3$ system, modified by off-valency additives, were the main objects of this research. Detailed studies were made of pressure-enforced ferroelectric-antiferroelectric transitions and electric-field-enforced antiferroelectric-ferroelectric transitions. An analysis of pulse-echo techniques for measurement of a complete set of elastic constants for a piezoelectric ceramic is given with attention to electrical boundary conditions. Several elastic constants were measured as functions of polarization and electric field through a ferroelectric hysteresis loop. The degradation of hysteresis loops with long-term cycling was studied. Hysteresis loops were obtained on a variety of $Pb(Zr,Ti)O_3$ single crystals. Ceramic compositions in the $PbZrO_3-BiFeO_3$ system were prepared, and although high permittivity (~500 at 25°C) was obtained on a few compositions, no direct evidence of ferroelectricity (hysteresis loops or piezoelectricity) was found. (auth)

**29152** (SC-R-64-104) PUBLIC RELEASES THROUGH 1963. Bibliography. (Sandia Corp., Albuquerque, N. Mex.). Jan. 1964. Contract AT(29-1)-789. 128p.

The bibliography, a revision of SCR-600, gives a cumulative numerical listing of the Sandia Corporation technical papers available to the public from the Office of Technical Services, Department of Commerce, Washington, D. C. 20230. Prices for printed, photostatic, facsimile, or microfilm copies are included for many of the listings. In addition to the document releases, the title list includes a section on engineering drawings and specifications on sale through AEC's Engineering Materials Section at Oak Ridge. The literature and engineering materials covered by the bibliography are made available to the public by Sandia Corporation, through the AEC's Division of Technical Information Extension. (auth)

**29153** (SC-TM-64-527) DETERMINATION OF CORRESPONDING POINTS ON A SODIUM VAPOR TRAIL. D. C. Jones (Sandia Lab., Albuquerque, N. Mex.). Apr. 1964. Contract AT(29-1)-789. 15p.

A general computer-oriented N-camera technique is developed for determining space coordinates of points on the centerline of a sodium vapor trail. A line-of-sight, $L_1$, from camera A is projected onto the image plate of camera B. The line determined by the projection of $L_1$ intersects the image trail on camera B in a point p. This point p is used to determine a line-of-sight, $L_2$, from camera B. The intersection of these two lines-of-sight determines a position on the sodium vapor trail. Thus, an image coordinate on camera B is determined which "corresponds" to an image coordinate on camera A. The accuracy of the procedure is limited by (1) camera triangulation, and (2) the precise determination of the centerline of the sodium vapor trail. (auth)

**29154** (SC-TM-64-576) CLIMATOLOGY OF TONOPAH TEST RANGE, 1963. J. R. Schaeffer (Sandia Lab., Albuquerque, N. Mex.). May 1964. Contract AT(29-1)-789. 58p.

Data are presented on the climatology of the Tonopah Test Range of the Nevada Test Site. Data are included on sky conditions, precipitation, temperature, relative humidity, station pressure, and surface winds during 1963. Summaries are included of the same elements and of upper winds based on 1961 to 1963 averages. (C.H.)

**29155** (SC-TM-64-604) A COMBINATION FINAL RINSING STATION USING FREON TF SOLVENT. R. C. Marsh (Sandia Lab., Albuquerque, N. Mex.). May 1964. Contract AT(29-2)-789. 17p.

A final cleaning or rinsing station is described which uses Freon TF solvent in a three-stage, ultrasonic bath, soft stream flush, and vapor degrease cycle. The rinsing system, which is built into a laminar flow work station, was developed from a need for a final rinsing process to remove particulate contamination from components at the latest possible stage before final packaging or "sealup". (auth)

**29156** (TID-3723) BIBLIOGRAPHIES OF ATOMIC ENERGY LITERATURE. Issued or in Progress During the Period April–May 1964. (Division of Technical Information, AEC). 16p.

A list is presented of 34 completed bibliographies and of 65 bibliographies in preparation during April and May 1964 of atomic energy literature. (R.E.U.)

**29157** (UCRL-7321) AREA MASKING WITH THE USE OF STANDARD INTENSIFICATION FOR UNDEREXPOSED AND/OR UNDERDEVELOPED NEGATIVES. Arthur M. Rogers (California. Univ., Livermore. Lawrence Radiation Lab.). June 25, 1963. Contract W-7405-eng-48. 5p.

Intensification combined with area masking can improve the negative quality where maximum intensification fails. The method comprises intensifying the negative in Victors Intensifier, contact printing the intensified negative on Kodalith ortho film, removing the intensifier from the original negative by a hypo soak, and making a master negative from a sandwich of the original negative (which now serves as area mask) and the ortho positive by contact printing on Kodalith ortho film. (D.L.C.)

**29158** (UCRL-7406) VACUUM TUBE FOR STUDYING THIN FILMS OF CHEMICALLY REACTIVE SEMICONDUCTORS. F. Wooten, G. A. Condas, and A. L. Greilich (California. Univ., Livermore. Lawrence Radiation Lab.). June 13, 1963. Contract W-7405-eng-48. 8p.

The design and fabrication of a vacuum tube for studying chemically reactive thin films are discussed. The tube design permits measurements of Hall effect, resistivity, Seebeck coefficient, optical properties, and photoemission. (auth)

**29159** (UCRL-7834) MEASURING ROTARY TABLE ANGLE ERROR. J. Bryan and O. Mohl (California. Univ., Livermore. Lawrence Radiation Lab.). Apr. 27, 1964. Contract W-7405-eng-48. 13p.

The angle errors of a rotary table can be accurately measured by stepping off the angles with an optical caliper and computing table error from (1) the error readings at each angle measured and (2) the cumulative caliper error that will be evident when the circle is closed at 360°, eliminating the necessity of adjusting the caliper to the exact setting. (auth)

**29160** PREPARATION AND CHARACTERIZATION OF $^{15}N^2H^3H$-LABELED DNA FROM BACILLUS SUBTILIS AND ESCHERICHIA COLI PHAGE T2. Walter Bodmer and Carl Schildkraut (Stanford Univ., Palo Alto, Calif.). Anal. Biochem., 8: 229-43(June 1964).

Bacillus subtilis and T2 phage were grown on a medium containing the following isotopically labeled compounds: $^{15}N^2H_4Cl$, thymidine-$^3H$, deuterated sugars, and deuterated amino acids. The growth rates, titers, and thymidine-$^3H$ uptake are reported. $^{15}N^2H^3H$-DNA was isolated from these two organisms. Some physical properties of the DNA samples are reported. Studies on genetic activity of the B. subtilis DNA did not reveal any change produced by the substitution of $^{15}N^2H^3H$ for $^{14}N^1H$. (auth)

**29161** PROCUREMENT AND DISTRIBUTION OF RADIOISOTOPES. D. J. Stevens (Commonwealth X-Ray and Radium Lab., Melbourne). J. Coll. Radiol. Australasia, 5: 55-6(June 1961).

Regulations governing the use of radioisotopes in Australia are reviewed, with special reference to recent changes in the regulations. Advisory services available through the Laboratory and the Commission, and the Customs Regulations pertaining to radioisotopes, are discussed. (BBB)

**29162** ELECTRON PARAMAGNETIC RESONANCE. S. A. Al'tschuler and B. M. Kozyrev. Translated from Elektronniy Paramagnitniy Rezonans, a publication of State Press for Physico-Mathematical Sciences, Moscow, 1961. New York, Academic Press, 1964. 377p. $13.50.

An attempt is made to give a complete review of experimental and theoretical research in the field of electron paramagnetic resonance. Theory and experimental data on ionic-crystal spectra are covered. The shape of a paramagnetic resonance absorption line in ionic crystals

and acoustic paramagnetic resonance are discussed. Metals and semiconductors, crystal defects, free radicals, double resonance, and applications of paramagnetic resonance are surveyed. Extensive references to the original literature are included, and extensive tabulation of all the experimental data and literature references on transition metal ions, complete to the end of 1958, is presented. (M.J.T.)

**29163** RECENT APPLICATIONS OF TRACERS IN THE PHYSICAL SCIENCES IN CANADA. R. H. Betts and J. A. Davies (Atomic Energy of Canada Ltd., Chalk River, Ont.). 12p. (CONF-539-4)

From Canadian Nuclear Association Conference on Canada's Role in a World of Expanding Nuclear Industry, Toronto, May 1964.

Some applications of tracers to the investigation of atomic diffusion and segregation in solids formation and properties of anodic films on metals, and stopping of energetic heavy ions in solids are reviewed, together with two technological applications of tracers. (D.C.W.)

# CORPORATE AUTHOR INDEX

This index contains entries for this period for all report literature and, in addition, for certain published literature items for which it is felt that a corporate approach is especially desirable, e.g., symposia, conference proceedings, and meetings.

Each entry under a corporate author is a shortened version of the title of the publication, followed by the *NSA* volume and abstract number. Report numbers are given in parentheses.

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Because of problems involving the mechanical preparation of this index, all accent marks are omitted. The following changes in spelling have been introduced to reduce some of the confusion which might result from omitting the accents:

| | | |
|---|---|---|
| ä | becomes | ae |
| ö | | oe |
| ø | | oe |
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# SUBJECT INDEX

Main entries in this index are generally specific materials, things, and processes. These are followed by modifiers that describe the properties of, and processes applied to, the main entries.

The number preceding the colon is the *NSA* volume number, and the number following is the abstract number. The designation (R) following the abstract number indicates that the abstract is of a progress report; (P) indicates a patent; and (T) indicates a translation. Abstracts for reports other than progress reports carry no letter designation. References to report numbers, where appropriate, are included after the abstract number of the citation. Published literature (journal article or book) is indentifiable by the absence of a report number.

### General Indexing Style

The user should bear in mind that the ideas presented in the original literature, rather than key words, have been indexed. The indexers have tried to select what seemed the most probable and logical place to look for typical information. Since it is not possible to anticipate where a user would look for information, numerous cross references are included to assist him in his search.

Experience in using an index of this type will be the best guide in obtaining the desired information, and a consideration of synonymous or closely related terms will prove valuable.

Information must be so indexed as to be of the greatest use to the greatest number of users. This requires that a topic be indexed to headings that most specifically describe it and not ordinarily to the headings that describe its ultimate use, nor to the general class headings that include the specific headings. For example, information on the treatment of thyroid disease with I-131 would be indexed under Thyroid Diseases and under Iodine Isotopes I-131, but not necessarily under Radiotherapy. A study of the effects of x radiation on hair would be indexed under both X Radiation and Hair. However, the information would not be indexed under the experimental animal, e.g., Rats, unless the report discusses the effects on rat hair as compared with the effect on the hair of other animals.

The broad, general class headings are used only for general information or for comprehensive reports or articles.

### Subject Heading Styles

Generally, the direct form of subject entry is used rather than inverted headings or, in some cases, subheadings; e.g., Amino Acids rather than Acids, amino; Helium Isotopes He-4 rather than Helium—isotopes He-4 or Helium—He-4 isotopes. Note, however, that in some cases modifying terms are used parenthetically in preference to a more direct type of entry which would result in the scattering of information. Organic compounds, however, are usually entered in the index in the inverted form so that substituted compounds can be listed near the parent compound; e.g., Benzene, Bromo- rather than Bromobenzene. In general, the style of nomenclature used is that of *Chemical Abstracts*, except that some items listed in that publication as subheadings are elevated to form part of the main heading; e.g., Butyric Acid, Methyl Ester rather than Butyric Acid—methyl ester.

### Alphabetization

Main headings are arranged according to the widely accepted word-by-word alphabetic system. A parenthetic qualifier following a main heading is disregarded in alphabetizing unless there are two or more headings identical except for the parenthetic qualifier, in which case the qualifier determines the order. Headings involving Greek letters are arranged as if the names of the letters were spelled out, e.g., Mesons ($\pi$), Mesons ($\xi$).

### Nomenclature of Inorganic Compounds

Inorganic compounds are indexed in the direct form, listing cations in the order of increasing valence in the case of polycationic salts of varying valence and in alphabetic order for polycationic salts in which all cations have the same valence; e.g., Sodium Aluminum Silicates and Potassium Sodium Sulfates.

### Multicomponent Systems

Multicomponent alloys, except well-known trade names are indexed under each element in the alloy.

Example: Aluminum–Chromium Alloys are indexed

ALUMINUM ALLOYS
  Al–Cr ...
CHROMIUM ALLOYS
  Al–Cr ...

Well-known alloys such as Hastelloy are indexed directly with cross references under the element components. Multicomponent systems of elements are indexed similarly.

Example: Silicon–Tungsten Systems are indexed

SILICON SYSTEMS
  Si–W ...
TUNGSTEN SYSTEMS
  Si–W ...

Multicomponent systems of compounds are similarly indexed under the compound.

### Physical States of Materials

In this subject index specification of the physical state of the material, if other than normal, is included in the modifying phrase.

### Modifying Phrases (Subheadings)

Descriptive phrases (modifiers), rather than ordinary subheadings, are used under the main headings to give a better indication of the material covered in an abstract than would be possible with only a word or two whenever it appears that such information would be useful. Such phrases are written so that the idea considered most important is presented first, should a not-too-awkward expression result. However, when using this index, the reader is advised to scan all modifiers under a main heading to determine whether any abstracts in addition to the most obvious should be consulted for the desired information. Many of the modifiers are designed to be read in inverted order or to be read with the main heading inserted at the position of the comma in order to obtain a meaningful phrase; e.g., Uranium—allotropic transformation temperatures of, effect of cooling rate on is read "effect of cooling rate on allotropic transformation temperatures of uranium." In many cases, the prepositions have been omitted from such phrases provided no ambiguity results from the omission.

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| 5 | 18-27955 | See HW-80567 |
| **CONF-524–** | **(American Institute of Mining, Metallurgical and Petroleum Engineers Annual Meeting, New York, Feb. 1964)** | |
| 6 | 18-28524 | ORINS. Gmelin, AED-CONF-64-006-7 |
| 7 | 18-28526 | ORINS. Gmelin, AED-CONF-64-006-1 |
| 8 | 18-27352 | ORINS. Gmelin, AED-CONF-64-006-9 |
| **CONF-529–** | **(AIPE-ASME Maintenance and Plant Engineering Conference, Los Angeles, Apr. 1964)** | |
| 1 | 18-29098 | ORINS |
| **CONF-531–** | **(American Physical Society 1964 Southwestern Meeting, Tucson, Ariz., Feb. 1964)** | |
| 2 | 18-28426 | ORINS. Gmelin, AED-CONF-64-010-4 |
| 3 | 18-28272 | ORINS. Gmelin, AED-CONF-64-010-2 |
| **CONF-534–** | **(Biophysical Society 8th Annual Meeting, Chicago, Feb. 1964)** | |
| 1 | 18-27609 | ORINS. Gmelin, AED-CONF-64-016-2 |
| **CONF-535–** | **(3rd Hypervelocity Techniques Symposium, Denver, Mar. 1964)** | |
| 1 | 18-28887 | ORINS. Gmelin, AED-CONF-64-027-1 |
| **CONF-536–** | **(National Winter Convention on Military Electronics, Los Angeles, Feb. 1964)** | |
| 1 | 18-27779 | ORINS. Gmelin, AED-CONF-64-007-4 |
| 3 | 18-27781 | ORINS. Gmelin, AED-CONF-64-007-2 |
| **CONF-537–** | **(USAEC-EURATOM Conference on Two Phase Flow Problems, Washington, D. C., Apr.–May 1964)** | |
| 1 | 18-27652 | See COO-926-31 |
| **CONF-538–** | **(23rd Annual Conference on Physical Electronics, Cambridge, Mass., Mar. 1963)** | |
| 1 | 18-28313 | ORINS |
| **CONF-539–** | **(Canadian Nuclear Association Conference on Canada's Role in a World of Expanding Nuclear Industry, Toronto, May 1964)** | |
| 1 | 18-27748 | ORINS |
| 2 | 18-27826 | ORINS |
| 3 | 18-29096 | ORINS |
| 4 | 18-29163 | ORINS |
| 5 | 18-29025 | ORINS |
| **CONF-540–** | **(American Society for Metals, Western Metal and Tool Conference, Los Angeles, Mar. 1964)** | |
| 1 | 18-27938 | ORINS |
| 2 | 18-27937 | ORINS |
| **CONF-541–** | **(International Solid State Circuits Conference, Philadelphia, Feb. 1964)** | |
| 1 | 18-27780 | ORINS. Gmelin, AED-CONF-64-017-1 |
| **COO–** | | |
| 926-31 | 18-27652 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 965-21 | 18-27061 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 1195-12 | 18-28565 | Dep.(mc); $3.60(fs), $1.13(mf) OTS |
| 1198-165 | 18-27949 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 1198-168 | 18-27950 | Dep.(mc); $4.60(fs), $1.43(mf) OTS |
| **CR–** | **(Misc.)** | |
| 69 | 18-28201 | See NP-13988 |
| **DASA–** | **(Misc.)** | |
| 1321 | 18-27633 | $17.00(OTS) |
| **DESY–** | **(German)** | |
| 64/5 | 18-28319 | Dep.(mc) |
| **DOFL-TR–** | **(Non-AEC)** | |
| 1104 | 18-29121 | |
| **DP–** | | |
| 844 | 18-29135 | Dep.; $2.25(OTS) |
| 886 | 18-27287 | Dep.; $0.50(OTS) |
| **DPST–** | | |
| 64-83-4 | 18-28916 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| **DUBNA REPORTS** | **(Russian)** | |
| See JINR (Russian) | | |
| **EDR–** | **(Misc.)** | |
| 3687(Vol.II) | 18-27360 | See TID-19978(Vol.II) |
| **EFINS–** | **(Misc.)** | |
| 63-3 | 18-28320 | Dep.(mc); $2.60(fs), $1.07(mf) OTS |
| **ER–** | **(Misc.)** | |
| 1399-2 | 18-27943 | See AD-426957 |
| 6793 | 18-28048 | See NP-13980 |
| **ETR–** | **(Belgian)** | |
| 150 | 18-27723 | See NP-13724 |
| 151 | 18-28047 | See NP-13725 |
| 152 | 18-27641 | See NP-13726 |
| 155 | 18-27616 | See NP-13932 |
| **EUR–** | **(European Atomic Energy Community)** | |
| 125.e | 18-27208 | Dep.(mc) |
| 1638.e | 18-28931 | Dep.(mc) |
| 1815.d,f,e | 18-28236 | Dep.(mc) |
| **EURAEC–** | | |

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|---|---|---|
| 806 | 18-27951 | Dep.(mc); $4.60(fs), $1.70(mf) OTS |
| 926 | 18-27952 | Dep.(mc); $2.60(fs), $0.86(mf) OTS |
| 973 | 18-27953 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 989 | 18-27925 | Dep.(mc); $6.60(fs), $2.27(mf) OTS |
| 1009 | 18-29006 | Dep.(mc); $12.50(fs), $5.51(mf) OTS |
| 1013 | 18-28932 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 1020 | 18-28039 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 1022 | 18-28040 | Dep.(mc); $4.60(fs), $1.67(mf) OTS |
| 1043 | 18-27972 | Dep.(mc); $3.60(fs), $1.13(mf) OTS |
| 1046 | 18-28041 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 1048 | 18-28042 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 1050 | 18-27653 | See GEAP-4577 |
| 1052 | 18-27492 | See GNEC-336 |
| 1057 | 18-27791 | See WCAP-2596 |
| 1071 | 18-27948 | See CEND-3107-210 |
| 1078 | 18-27882 | See GEAP-4473 |
| 1080 | 18-28958 | See ACNP-64023 |
| **FN-E–** | **(Italian)** | |
| 43 | 18-28042 | See EURAEC-1048 |
| **FTD-TT–** | **(Non-AEC)** | |
| 63-1061 | 18-27639 | OTS |
| **GA–** | **(Misc.)** | |
| 4512 | 18-29037 | Dep.(mc); $2.60(fs), $0.86(mf) OTS |
| **GAMD–** | **(Misc.)** | |
| 4904 | 18-27954 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **GE-EE–** | **(Non-AEC)** | |
| 62-6 | 18-28753 | See AD-411584 |
| **GEAP–** | **(Misc.)** | |
| 4407 | 18-28999 | Dep.(mc); $2.60(fs), $1.10(mf) OTS |
| 4418(Vol.I) | 18-29038 | Dep.; $3.00(OTS) |
| 4418(Vol.II) | 18-29039 | Dep.; $5.50(OTS) |
| 4473 | 18-27882 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 4480 | 18-29040 | Dep.(mc); $7.60(fs), $2.51(mf) OTS |
| 4503 | 18-29000 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| 4577 | 18-27653 | Dep.(mc); $6.60(fs), $2.06(mf) OTS |
| 4606 | 18-29041 | Dep.(mc); $3.60(fs), $1.31(mf) OTS |
| 4609 | 18-29042 | Dep.(mc); $4.60(fs), $1.58(mf) OTS |
| **GEMP–** | **(Misc.)** | |
| 82 | 18-28933 | Dep.; $0.50(OTS) |
| **GNEC–** | | |
| 336 | 18-27492 | Dep.(mc); $8.10(fs), $2.84(mf) OTS |
| 345 | 18-29043 | Dep.(mc); $10.10(fs), $3.95(mf) OTS |
| **HMI-B–** | **(German)** | |
| 27 | 18-27951 | See EURAEC-806 |
| **HW–** | | |
| 75065 | 18-27855 | Dep.; $1.00(OTS) |
| 75715 | 18-29144 | Dep.(mc); $5.60(fs), $1.88(mf) OTS |
| 78321 | 18-27683 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 79280 | 18-28917 | Dep.; $2.75(OTS) |
| 79762(Pt.2) | 18-29136 | Dep.; $1.25(OTS) |
| 80284 | 18-29046 | Dep.; $2.50(OTS) |
| 80391(Rev.1) | 18-27654 | Dep.; $0.50(OTS) |
| 80567 | 18-27955 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 81076 | 18-27843 | Dep.; $0.50(OTS) |
| **HW-SA–** | | |
| 3104 | 18-29003 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| **IAN-A–** | **(Colombia)** | |
| 1 | 18-27816 | Dep.(mc) |
| 2 | 18-27028 | Dep.(mc) |
| **IAN-F–** | **(Colombia)** | |
| 1 | 18-28566 | Dep.(mc) |
| **IAN-I–** | **(Colombia)** | |
| 1 | 18-28045 | Dep.(mc) |
| **IDO–** | | |
| 14622 | 18-29137 | Dep.; $1.75(OTS) |
| 14629 | 18-29138 | Dep.; $0.50(OTS) |
| 14637 | 18-27614 | Dep.; $0.50(OTS) |
| 16929(Rev.1) | 18-29105 | Dep.; $2.50(OTS) |
| **IITRI–** | **(Misc.)** | |
| 578P22-10 | 18-28934 | Dep.(mc); $3.60(fs), $1.25(mf) OTS |
| B6007-6 | 18-27858 | $3.60(OTS) |
| T6042-5 | 18-28935 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **IMM-NYU–** | **(Misc.)** | |
| 322 | 18-28089 | Dep.(mc); $2.60(fs), $0.98(mf) OTS |
| **IMP-AEC–** | | |
| 29 | 18-28140 | Phys. Fluids, 7: 1011-22(1964) |
| **INSJ–** | **(Japanese)** | |
| 70 | 18-28321 | Dep.(mc) |
| **IS–** | | |
| 744 | 18-27976 | Trans. Quart., 57: 464-73(1964) |
| 745 | 18-27956 | Dep.; $2.50(OTS) |
| 791 | 18-28390 | Phys. Rev., 135: B241-8(1964) |
| 863 | 18-28090 | Dep.; $0.50(OTS) |
| 871 | 18-27357 | Dep.; $2.50(OTS) |
| **ITP–** | **(Non-AEC)** | |
| 110 | 18-28394 | See TID-20434 |
| **JINR–** | **(Russian)** | |
| D-1570 | 18-28567 | Dep.(mc) |
| E-1621 | 18-28568 | Dep.(mc) |
| P-1639 | 18-28322 | Dep.(mc) |
| **JPRS–** | **(Non-AEC)** | |
| 25029 | 18-28274 | $2.50(OTS) |
| **KAPL–** | | |
| 2000-21 | 18-27859 | Dep.; $2.25(OTS) |
| **KFK–** | **(German)** | |
| 196 | 18-27358 | Dep.(mc) |
| 199 | 18-27288 | Dep.(mc) |
| 200 | 18-27039 | Arzneimittel-Forsch., 13: 787-92(1963) |
| 207 | 18-27339 | Z. Anal. Chem., 200: 257-65(1964) |
| **KFK-tr–** | **(German)** | |
| 150 | 18-27362 | Dep.(mc); $1.60(fs), $0.80(mf) JCL |
| **KRB–** | **(German)** | |
| 1963/3 | 18-29050 | Dep.(mc) |
| **LA–** | | |
| 2485 | 18-27917 | Dep.; $1.00(OTS) |
| 3061 | 18-27655 | Dep.; $2.60(fs), $1.04(mf) OTS |
| 3066 | 18-28323 | Dep.; $0.75(OTS) |
| 3077 | 18-27656 | Dep.; $2.00(OTS) |
| **LADC–** | | |
| 5459 | 18-28519 | Phys. Today, 17: 50-1(1964) |
| 5832 | 18-27981 | Carbon, 1: 181-3(1964) |
| 5972 | 18-27437 | Phys. Rev., 135: A434-6(1964) |
| 6159 | 18-28623 | J. Inorg. Nucl. Chem., 26: 1117-20(1964) |
| 6265 | 18-29092 | Trans. Am. Nucl. Soc., 7: 195-6(1964) |

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|---|---|---|
| **LAMS–** | | |
| 2968 | 18-29106 | Dep.; $0.75(OTS) |
| 3070 | 18-28496 | Dep.; $2.00(OTS) |
| 3071 | 18-27700 | Dep.; $0.50(OTS) |
| 3075 | 18-27844 | Dep.; $1.75(OTS) |
| **LNF–** | **(Italian)** | |
| 64/6 | 18-28324 | Dep.(mc) |
| **LRP–** | **(Swiss)** | |
| 13-64 | 18-28760 | Dep.(mc) |
| **MATT–** | | |
| 252 | 18-28761 | Dep.(mc); $5.60(fs), $1.94(mf) OTS |
| **MIT–** | **(Misc.)** | |
| 2098-41 | 18-28400 | Phys. Rev. Letters, 12: 739-42(1964) |
| **MITNE–** | **(Misc.)** | |
| 37 | 18-28569 | $13.00(OTS) |
| 43 | 18-27615 | Dep.(mc); $3.60(fs), $1.13(mf) OTS |
| **ML–** | **(Misc.)** | |
| 1161 | 18-28769 | See TID-20644 |
| **ML-TDR–** | **(Non-AEC)** | |
| 64-59 | 18-27959 | |
| 64-108 | 18-27918 | |
| **MLM–** | | |
| 834 | 18-27787 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 1183 | 18-27810 | Dep.; $2.60(fs), $1.10(mf) OTS |
| 1185 | 18-29145 | Dep.; $2.60(fs), $1.10(mf) OTS |
| 1192 | 18-29146 | Dep.; $2.60(fs), $1.04(mf) OTS |
| **MND–** | **(Misc.)** | |
| 2933-2 | 18-28306 | Dep.; $2.50(OTS) |
| **MRC-TSR–** | **(Non-AEC)** | |
| 403 | 18-27840 | See AD-411772 |
| **MSAR–** | **(Misc.)** | |
| 63-116 | 18-27960 | |
| **MTI–** | **(Misc.)** | |
| 63TM8 | 18-27684 | |
| **N–** | **(Misc.)** | |
| 64-17684 | 18-28048 | See NP-13980 |
| **NAA-SR–** | | |
| 6508 | 18-29051 | Dep.; $1.50(OTS) |
| 7929 | 18-27845 | Dep.; $0.75(OTS) |
| 8683 | 18-28529 | Dep.; $0.50(OTS) |
| 9090 | 18-28919 | Dep.(mc); $16.50(fs), $7.65(mf) OTS |
| 9374 | 18-27961 | Dep.; $0.75(OTS) |
| 9390 | 18-28960 | Dep.; $0.50(OTS) |
| 9584 | 18-29052 | Dep.; $0.75(OTS) |
| 9715 | 18-29107 | Dep.; $1.25(OTS) |
| **NAA-SR-Memo–** | | |
| 8968 | 18-28920 | Dep.(mc); $4.60(fs), $1.55(mf) OTS |
| **NASA-CR–** | **(Non-AEC)** | |
| 56004 | 18-28048 | See NP-13980 |
| **NASA-SP–** | **(Misc.)** | |
| 41 | 18-27885 | Dep.(mc); $5.00(OTS) |
| **NASA-TN–** | **(Misc.)** | |
| D-2287 | 18-27962 | $0.50(OTS) |

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|---|---|---|
| **NMI–** | **(Misc.)** | |
| 1123 | 18-27920 | Dep.(mc); $2.60(fs), $0.86(mf) OTS |
| 1129 | 18-27921 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 1131 | 18-27919 | $2.60(fs), $1.01(mf) OTS |
| **NP–** | **(AEC File No. for Non-AEC Reports)** | |
| 13724 | 18-27723 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 13725 | 18-28047 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 13726 | 18-27641 | $3.60(fs), $1.37(mf) OTS |
| 13932 | 18-27616 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| 13980 | 18-28048 | $3.60 (OTS) |
| 13988 | 18-28201 | |
| 13994 | 18-29148 | Dep.(mc) |
| 13995 | 18-28570 | Dep.(mc) |
| 13996 | 18-28571 | Dep.(mc) |
| 13997 | 18-27617 | Dep.(mc) |
| 13999 | 18-28180 | Dep.(mc) |
| 14015 | 18-28185 | Dep.(mc) |
| 14035 | 18-27359 | |
| **NRC–** | **(Canadian)** | |
| 7901 | 18-28589 | Can. J. Phys., 42: 1097-1100(1964) |
| 7920 | 18-27373 | Can. J. Phys., 42: 1256-69(1964) |
| 7921 | 18-28275 | Can. J. Phys., 42: 1135-48(1964) |
| 7956 | 18-27514 | J. Am. Chem. Soc., 86: 2325-9(1964) |
| **NRL-TR–** | **(Non-AEC)** | |
| 43 | 18-27690 | $9.10(OTS) |
| **NUMEC–** | | |
| 2389-1 | 18-27863 | Dep.(mc); $3.60(fs), $1.40(mf) OTS |
| **NYO–** | | |
| 1680-1 | 18-27062 | Dep.(mc); $3.60(fs), $1.37(mf) OTS |
| 1957-34 | 18-27595 | Tetrahedron Letters, No. 29, 2033-6(1963) |
| 1957-35 | 18-27593 | Radiochim. Acta, 2: 112-116(1964) |
| 2363-1 | 18-27701 | Dep.(mc); $6.60(fs), $2.30(mf) OTS |
| 2737-1 | 18-27063 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2907-2 | 18-28936 | Dep.(mc); $5.60(fs), $1.85(mf) OTS |
| 3034-1 | 18-29149 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 10497 | 18-27289 | Dep.(mc); $2.60(fs), $1.07(mf) OTS |
| **ORNL–** | | |
| 2496 | 18-27963 | Dep.; $1.00(OTS) |
| 3553 | 18-27964 | Dep.; $1.25(OTS) |
| 3556 | 18-27965 | Dep.; $1.75(OTS) |
| 3577 | 18-27864 | Dep.; $1.60(fs), $0.80(mf) OTS |
| 3578 | 18-27752 | Dep.; $2.75(OTS) |
| 3592 | 18-27847 | Dep.; $8.10(fs), $2.75(mf) OTS |
| 3596 | 18-27619 | Dep.; $0.50(OTS) |
| 3597 | 18-27280 | Dep.; $2.00(OTS) |
| 3600 | 18-27966 | Dep.; $3.50(OTS) |
| 3601 | 18-27002 | Dep.(mc); $15.50(fs), $7.16(mf) OTS |
| 3606 | 18-27831 | Dep.; $1.25(OTS) |
| 3615 | 18-28572 | Dep.; $2.25(OTS) |
| 3616 | 18-27865 | Dep.; $7.60(fs), $2.42(mf) OTS |
| 3617 | 18-27967 | Dep.; $12.00(fs), $5.06(mf) OTS |
| 3630 | 18-28091 | Dep.; $2.50(OTS) |
| 3632 | 18-27922 | Dep.; $2.00(OTS) |
| 3635 | 18-28049 | Dep.; $2.00(OTS) |
| 3636 | 18-28576 | Dep.; $0.75(OTS) |
| 3637 | 18-28577 | Dep.; $0.50(OTS) |
| 3638 | 18-28578 | Dep.; $2.25(OTS) |
| 3639 | 18-29004 | Dep.; $5.60(fs), $1.73(mf) OTS |
| **ORNL-TM–** | | |
| 14 | 18-27904 | Dep.(mc); $13.00(fs), $5.69(mf) OTS |
| 198 | 18-27811 | Dep.(mc); $3.60(fs), $1.37(mf) OTS |
| 415 | 18-27812 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| 428 | 18-27813 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 434 | 18-27814 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |

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| 530(Rev.) | 18-27832 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 718 | 18-27815 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 810 | 18-29123 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 812 | 18-29053 | Dep.(mc); $11.50(fs), $4.91(mf) OTS |
| 832 | 18-29054 | Dep.(mc); $8.10(fs), $2.66(mf) OTS |
| 833 | 18-27618 | Dep.(mc); $7.60(fs), $2.42(mf) OTS |
| 839 | 18-29139 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 856 | 18-29055 | Dep.(mc); $3.60(fs), $1.40(mf) OTS |
| 864 | 18-27756 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 871 | 18-29056 | Dep.(mc); $4.60(fs), $1.56(mf) OTS |
| 885 | 18-27757 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| **ORNL-tr-** | | |
| 108 | 18-27662 | Dep.(mc); $1.10(fs), $0.80(mf) JCL or OTS |
| 118 | 18-27642 | Dep.(mc); $2.60(fs), $0.83(mf) JCL |
| 143 | 18-29140 | Dep.(mc); $2.60(fs), $0.86(mf) JCL |
| 149 | 18-27693 | Dep.(mc); $1.60(fs), $0.80(mf) JCL |
| 150 | 18-27694 | Dep.(mc); $1.60(fs), $0.80(mf) JCL |
| 186 | 18-27292 | Dep.(mc); $1.10(fs), $0.80(mf) JCL |
| 190 | 18-28582 | Dep.(mc); $1.10(fs), $0.80(mf) JCL |
| **ORO-** | | |
| 3154-7 | 18-29043 | See GNEC-345 |
| **OTS-** | **(Misc.)** | |
| 62-11066/5-6 | 18-27704 | $3.25(OTS) |
| 64-31455 | 18-28274 | See JPRS-25029 |
| **PA-TM-** | **(Non-AEC)** | |
| 1271 | 18-27817 | |
| **PAN-** | **(Polish)** | |
| 294 | 18-28186 | Dep. |
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| 960,712 | 18-27839 | |
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| 158,419 | 18-27353 | |
| 158,683 | 18-27785 | |
| **PB-** | **(Non-AEC)** | |
| 181469 | 18-27818 | $6.00(OTS) |
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| 239F | 18-27702 | Dep. (OTS) |
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| 491E | 18-28627 | Nucl. Phys., 53: 558-76(1964) |
| 494E | 18-28628 | Nucl. Phys., 53: 577-92(1964) |
| **PUC-** | | |
| 1964-145 | 18-28705 | Phys. Rev. Letters, 12: 726-8(1964) |
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| 2309 | 18-27968 | |
| **PWAC-** | **(Misc.)** | |
| 401(Pt.II) | 18-27658 | Dep.; $0.75(OTS) |
| 423 | 18-27758 | Dep.; $1.50(OTS) |
| **R-** | **(Misc.)** | |
| 146-4 | 18-28234 | See AD-418676 |
| 146-6 | 18-28235 | See AD-419133 |
| 425-PR | 18-27691 | |
| 2266 | 18-27952 | See EURAEC-926 |
| 2275 | 18-27953 | See EURAEC-973 |
| 64SD28 | 18-28237 | |
| **RADC-TDR-** | **(Misc.)** | |
| 63-465(Vol.1) | 18-28762 | $4.60(OTS) |
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| 11 | 18-28754 | See AD-415622 |
| **RRL-** | | |
| 122 | 18-27527 | J. Phys. Chem., 68: 1576-9(1964) |
| 123 | 18-27487 | J. Phys. Chem., 68: 1392-8(1964) |
| 130 | 18-27528 | J. Phys. Chem., 68: 1618-20(1964) |
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| (64)-1 | 18-27759 | Dep.(mc) |
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| 18916 | 18-27418 | J. Inorg. Nucl. Chem., 26: 1045-56(1964) |
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| 19299 | 18-28346 | Nuovo Cimento (10), 32: 919-38(1964) |
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| 19867 | 18-28222 | Proc. Intern. Space Sci. Symp., 4th, Warsaw, 1963, 797-818(1964) |
| 19978(Vol.II) | 18-27360 | Dep.(mc); $13.00(fs), $5.78(mf) OTS |
| 20087 | 18-28377 | Phys. Rev., 135: B180-2(1964) |
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| 20266 | 18-28008 | Phys. Rev., 135: A426-7(1964) |
| 20282 | 18-27424 | J. Phys. Chem., 68: 1275-8(1964) |
| 20434 | 18-28394 | Phys. Rev., 135: B267-71(1964) |
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| 7626 | 18-28010 | Phys. Rev., 135: A495-505(1964) |
| 7638 | 18-27427 | J. Phys. Chem., 68: 1516-23(1964) |
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| 10819 | 18-28378 | Phys. Rev., 135: B183-7(1964) |
| 10870 | 18-28191 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
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| 10950 Rev. | 18-28381 | See UCRL-10950 |
| 10992 | 18-28384 | Phys. Rev., 135: B208-13(1964) |
| 11083 | 18-28689 | Phys. Rev., 135: B22-34(1964) |
| 11129 | 18-28704 | Phys. Rev., 135: A358-61(1964) |
| 11167 | 18-28385 | Phys. Rev., 135: B214-19(1964) |
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